SURVEY METHODS

1958

Cooperative ECONOMIC INSECT REPORT

Issued by

PLANT PEST CONTROL DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

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PLANT PEST CONTROL DIVISION

PLANT PEST SURVEY SECTION

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COOPERATIVE ECONOMIC INSECT REPORT

SURVEY METHODS

Contents

PICTORIAL KEYS

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These survey methods have been brought together at the suggestion of the Entomological Society of America Survey Advisory Committee and other entomological workers.

(Re-issued May 1958)

CHINCH BUG

Cooperative surveys to determine populations of hibernating chinch bugs (Blissus leucopterus) are made annually in several Central States. The work is conducted during November and December in areas suspected of harboring infestations. Overwintering occurs in several species of bunchgrasses, including little bluestem, big bluestem, and broomsedge. Five samples of bunchgrass are collected at widely separated points in each county surveyed. Each sample consists of a bunch of grass including the crown, from 3.5 to 4.5 inches in diameter, which is cut from the sod clump with a tilling spade. After trimming, the sample is placed in a double paper bag on which the location, date, and other pertinent details are recorded. By examining samples of the grass clumps in the laboratory, hibernating bugs are detected and abundance determined. As counts are made the number of bugs in the sample is converted to a number per square foot and rated according to the following table:

Classification	Number of bugs per square foot	Rating
Non-economic	0 - 250	1
Light	250 - 500	2
Moderate	500 - 1,000	3
Severe	1,000 - 2,000	4
Very Severe	2,000 or more	5

A rating is assigned to each county based on stop ratings and percentage of land under cultivation in the county. The greater the percentage of cultivated land the less protective cover available for hibernation and, consequently, a reduced population in comparison to crops that may be attacked.

Information obtained from these surveys provides a basis for preliminary estimate of control needs as well as a record of hibernating populations; however, weather conditions the following spring determine the severity of infestations. (C. W. Shockley)

EUROPEAN CORN BORER

Abundance Survey-- The recommended procedure for making European corn borer (Pyrausta nubilalis) fall abundance survey is to make 10 observations, or sample counts, per county. If it is found that contiguous counties cannot be sampled utilizing 10 counts per county, a survey on a district basis is preferred which averages about 5 counts per county. Fewer than 5 counts per county is not recommended.

An observation or sample count is obtained in a prescribed manner. The locations of the sampling points are distributed uniformly by marking them on a map of the area to be surveyed. The observer is instructed to proceed to the point marked on the map and sample the first corn field encountered. The sample is obtained after walking 50 paces into the field from the most accessible point. Beginning with the first plant on the observer's right, 25 consecutive plants are examined for infestation and the number of infested plants recorded. The last two infested plants encountered in the count of 25 are dissected and the number and stages of borers found are recorded. The product of percent infestation and average borers per plant becomes the estimate of the field population expressed as borers per 100 plants. The observer than proceeds to the next location and so on throughout the survey.

Distribution Survey-- The distribution surveys are less formalized than the abundance survey. In searching for new infestations available,time and number of observers are the limiting factors. Recommendations have been to examine as many fields as possible which are deemed most likely to harbor the borer. For example, mid-season surveys should be made in earliest fields in the area under observation, and September or later surveys should be confined to late fields. Concentrations of borers if present are expected to be more abundant in the respective types of fields.

Service Survey-- Service surveys to determine the need for control should be organized so that observations can be made by state zones (corn testing districts, crop reporting districts, etc.) or at strategic points in the state. The number of observations is dependent on funds and assistants available. Observations to be made include periodic counts on development of the borer as it changes from a dormant condition to an active one and larvae change to the pupal state. The emergence of moths is used as a criterion of the probable time of the beginning of egg deposition which is the forecast of the beginning of the critical period in corn borer control. Sufficient plants are examined in a number of localities to determine the egg load. When the egg load approaches 50 masses per 100 plants on corn approximately 35 inches in extended leaf height in any locality, the situation is considered serious enough to advise treatment of similar fields with insecticides. If the egg load builds up rapidly and is general over a large area, dealers are to be alerted to the probable heavy demand for insecticide materials. In any case farmers are urged to make counts in their own fields to determine the need for the use of insecticides.

Similar observations are made on the progress of the development of the second generation borer in the more advanced corn, but treatment is not recommended until the egg load approaches 100 masses per 100 plants. However, treatment of mid-season or late corn is not recommended until the egg load approaches 100 masses per 100 plants. (Elmer W. Beck)

WHEAT STEM SAWFLY

Wheat stem sawfly (Cephus cinctus) surveys are conducted at the conclusion of harvest in wheat fields in the northern Great Plains Area. The survey is made of the overwintering larval population by examining two samples in each of 10 well-distributed fields in each county. One sample is taken near the margin of the field within the first few drill rows, and the other at approximately the center of the field. At each sample location, 50 consecutive wheat stems of a drill row are examined for stubs cut off by the sawfly. The total number of these sawfly stubs found in the two samples is recorded as the percentage of infestation for the field.

Upon completion of the survey, the fields are placed into one of four classifications based on their percentage of infestation as follows:

CLASSIFICATION	PERCENT OF STEMS INFESTED
Light	Trace - 5
Moderate	6 - 24
Heavy	25 - 39
Severe	40 - 100

A map of the infestation is prepared by locating each classified field on a map of the surveyed region and delimiting the areas of different population abundance. The information obtained from the survey provides a basis for determining the extent of the infestation and makes certain data available that assist in making an appraisal of the wheat loss caused by the sawfly. (E. G. Davis)

SPITTLEBUG SURVEY IN ILLINOIS

With an increase in spittlebug infestations up to economic levels in Illinois, it was considered desirable to attempt the prediction of the potential populations that might occur on legume crops in the spring. Based on biological data from Ohio and field experience in Illinois, a survey technique for this purpose was developed in Illinois for use in 1951 and 1952. On the basis of data obtained in an adult spittlebug survey in the fall, probable damage ratings were determined for the following spring.

In late August or early September after the adult spittlebug populations became fairly stable, (determined by regular sampling of a few fields) 30 counties were surveyed in Illinois to determine adult populations. Ten fields were selected at random in each county. Ten individual sweeps (standard 15" net-180° sweep) were made in each field and each recorded separately on a special form.* The condition of the field and other pertinent data were also recorded. Based on the average number of adult spittlebugs per sweep in each county, predictions were made for the areas most likely to be subjected to economic losses the following spring.

By assuming that for each adult spittlebug per sweep there would likely be one-fourth to one-half spittlebug nymph per stem the following spring (Ohio's results), estimates were made of the acreage of new stands worthy of treatment. Treatment was recommended on first-year hay crop fields in those areas where an average of one-half or more nymphs per stem was anticipated. As a followup in late May, nymphal counts were made on a 100-stem sample in many of the fall-survey fields and observers found that for county averages the predicted and actual numbers of nymphs per 100 stems were substantially the same.

This survey method gives actual figures upon which to base and check predictions. Since by this method it is possible to obtain a quantitative cross section of populations in old and new fields and in fields of various mixtures of grasses and legumes, mixed legumes, and straight stands of legumes, the survey data is of value to research and extension workers alike. (H. B. Petty)

*Spittlebug Survey

Fall. Date ______________________. County ______________________.
Crop ______________________________. Old. New.
Condition: Good. Fair. Poor. Height ______ inches. Clipped. Unclipped.
Location: N. S. E. W. side of Rt. ______. ________ miles N. S. E. W. of ______________________________.
________ miles N. S. E. W. of ______________________________.
Adults per sweep: 1. ______. 2. ______. 3. ______. 4. ______. 5. ______. 6. ______.
7. ______ 8. ______. 9. ______. 10. ______. Average __________.
Spittlebug masses observed - Yes. No.

Spring. Date ______________________.
Infestation per 10 stems: 1. a. _____ b. _____. 2. a. _____ b. _____. 3. a. ______
b. ______ 4. a. ______ b. ______. 5. a. ______ b. ______ 6. a. ______ b. ______
7. a. ______ b. ______ 8. a. ______ b. ______ 9. a. ______ b. ______.
10. a. ______ b. ______. Total a. ______ b. ______.
a= Infested plants.
b= Number of nymphs.
Adults observed. Yes. No.

Notes: ______________________________

GRASSHOPPERS

Adult Survey (Revised Instructions)*

Soon after grasshoppers have dispersed from nymphal concentrations and have reached the adult stage all infested areas should be surveyed. This survey should be timed to coincide with peak populations, enabling completion of the survey before appreciable decline in grasshopper numbers occurs. Known infestations and new infestations should be classified and mapped according to the following table.

Grasshopper Adult Infestations

No. of Adults Per Square Yard			
Field	Margin	Rating	Map Color
0-2	5-10	1.0	White
3-7	11-20	2.0	Green
8-14	21-40	3.0	Orange
15-28	41-80	4.0	Blue
Over 28	Over 80	5.0	Red

Evaluation of Adult Populations

To obtain an estimate of the number of adult grasshoppers per square yard, a system of multiple estimates should be used. This involves a series of actual counts of grasshoppers as they leave a square foot, selected by the surveyor well ahead of his line of march. Eighteen counts should be made 15-20 paces apart through the range, field or margin being sampled. At the completion of the count, the total number of grasshoppers from the 18 square feet should be computed. This total divided by 2 will convert this figure to the number of grasshoppers per square yard. It is advisable to occasionally lay off a square foot on the ground to keep the size of this unit area fixed in mind. The time of day, temperature, density and height of vegetation all affect grasshopper activity and should be considered in making counts of grasshoppers.

Where hatching has been irregular and where populations of mixed species exist, nymphs may be present with adult grasshoppers. In making the adult survey, if the nymphs are in the fourth or fifth instars, they should be counted as adults. If the occurrence of large numbers of first to third instars of nymphs of economic importance is encountered frequently in an area, it is advisable to delay the survey until a later date. If a delay is impractical and this situation involves only an occasional stop, reduce the count of first to third instar nymphs to one-third before the figure in terms of adults is recorded on the record sheet.

In large field areas where fields consist of 80 acres or more and in range areas where the vegetation is uniform only one habitat need be examined at each stop.

* This replaces instructions for adult survey in Cooperative Economic Insect Report Survey Methods (Reissued September 1955), page 5.

In diversified crop areas where fields are usually less than 40 acres, or in range areas where several vegetative types exist, two or more fields, and in range, each of the habitats should be sampled. The population in each crop and habitat should be determined. These populations should be averaged to determine a population for the stop. This average population of all fields or habitats sampled is used to rate the stop.

In all cases, the observer should walk sufficiently far into each field to insure that the count of grasshoppers represents an average value for the field examined. Likewise, on the margin, a sufficient length of the margin should be examined to insure an average count. Population counts on the margin should also represent an average value for the entire width, from the edge of the road to the edge of the field. Most margins will be 2 or more rods wide and for all such margins, the population count should be recorded as an average for the entire width and the length examined. However, for narrow margins of less than 2 rods, the population count should be reduced proportionately. For example, the population count on a one-rod margin would be reduced one-half. When there is no distinct vegetative difference between the field and the margin and there is no concentration of grasshoppers along the margin, the field count should be recorded for the stop. No separate margin count need be made. This would apply to some ungraded roads or to roads through crops.

After the number of grasshoppers per square yard has been determined for any stop, a rating for that stop is recorded on Form GC 67 from the adult rating table found on p. 543. When marginal and field ratings differ, the higher rating should be assigned to the stop. The field counts are not to be combined with the marginal counts and averaged to obtain stop ratings.

The stops in the various crops and range should be well distributed and in approximate proportion to their relative county acreage.

The adult survey should be started in each state at the earliest possible time, determined by the maturity and behavior of the grasshoppers, and completed, where possible, within a period of two weeks. Actually the best survey is that which is the culmination of a whole season's observation of grasshopper development by the surveyor who had the opportunity to observe them in given areas. From 5 to 15 stops should be made in each county, depending on the nature of the infestation, the supervisor's knowledge of the infestation, and the size of the county. Fewer survey stops are required in an area which is lightly and evenly infested than in an area which is heavily and irregularly infested. In small counties and in counties where the supervisor is familiar with the infestation, 5 stops will usually be adequate. Areas in which infestations are of doubtful degrees of intensity, and areas which border known heavy infestations should be given more attention, and as many as 10 stops may be needed. Only in large counties or ones with extremely irregular infestations should it be necessary to make as many as 15 stops. In order to locate the boundaries of infestations more definitely, exploratory examinations, which need not be formally recorded, may be made in addition to the regular stops. (PPC Regional Survey Entomologists).

HESSIAN FLY

Surveys to determine infestations of hessian fly (Phytophaga destructor) are made annually near harvest time in the winter wheat region and in California. If there are relatively few reports of damage in May or June, the surveys may be limited or less intensively made in some areas or states. For an intensive survey, five or more samples of wheat are collected at separated points in each county surveyed. A sample consists of 50 stems of wheat chosen at random from a larger sample pulled from a field of wheat. The percent of stems infested with puparia of the hessian fly is recorded for each sample along with location and date of collection. Often it becomes desirable to make examinations later at the field station. If so, the samples are placed in individual paper bags or tied with fine wire, labeled and stored in dry place until examined. A county, an assembly of counties, or an area is rated on the average infestation recorded from the samples examined as follows:

Average Infestation	Infestation Rating
7.5 percent	Low
17.5 percent	Moderate
27.5 or more percent	Heavy

The ratings indicate whether low, moderate, or heavy populations of the fly exist in the wheat stubble and the need for publicizing control measures. (W. B. Cartwright)

SUGARCANE BORER

Determining Infestation at Time of Harvest

Method Used in Louisiana: Surveys to determine sugarcane borer (Diatraea saccharalis) infestations in Louisiana are made at time of harvest each year. Examinations are made on 10 plantations, each being representative of a surrounding area producing one-tenth of the sugar yield for the state. Six fields in representative locations on the plantation and divided among varieties and soil types in proportion to their acreage importance in the district represented by the plantation are surveyed. Each field infestation average is given equal weight in determining the plantation average, and each plantation average is given equal weight in determining the infestation average for the state. Examinations are made between October 20 and December 15. Infestation counts consist of the percentage of joints bored as determined from the total number of joints and total bored joints on 100 stalks in each field. Ten samples of 10 consecutive stalks each are examined in 10 locations of each field. Five of the samples are taken on two adjoining rows running lengthwise and one-third of the distance in from one side of the field. The samples are alternated between the two rows and spaced equidistant apart for the entire length of the field. The other five samples are similarly taken one-third of the distance in from the other side of the field. If up to 10 percent of the joints are bored infestation is considered to be very light; 10 to 20, light; 20 to 30, moderate; and over 30, very severe. The percentage of crop loss for each 1 percent joints bored is conservatively estimated to be three-fourths of 1 percent.

Method Used in Florida: Surveys to determine sugarcane borer infestations in Florida are made, also, at time of harvest each year. Examinations are made in approximately 40 representative fields of sugarcane well distributed over the sugar producing area. Individual fields are sampled by counting the total number of joints and externally apparent bored joints of 10 consecutive stalks in each of 5 locations. The samples are taken about 100 feet apart in the central one-third section of the field. Up to 5 percent of the joints bored is considered to be a light infestation; 5 to 10 moderate; and over 10 heavy. The percentage of crop loss for each 1 percent joints bored is conservatively estimated to be 1 percent. In Florida the average infestation is less and the loss per unit of infestation is more than it is in Louisiana.

Determining Number of Overwintering Sugarcane Borers

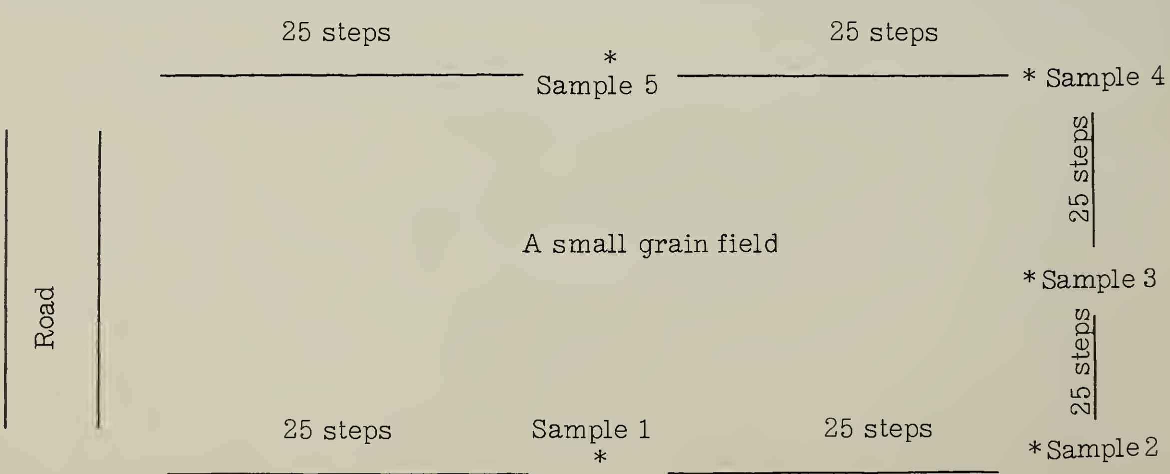
Surveys to determine the number of overwintering sugarcane borers in Louisiana are made during February to obtain an estimate of the probable infestation and control needs during the coming spring and summer. Examinations are made on 10 plantations evenly distributed over that section of the sugar producing area in which the borer is most likely to cause serious damage. Three representative fields are examined on each plantation. Although most examinations are made in the cane trash of ratoon fields which make up most of the acreage, some are also made in young shoots from summer-planted and fall-planted cane. Ten random samples of 10 linear feet of row each are examined in each field for overwintering borers. These counts are then converted into number of overwintering borers per acre. In cane trash 0 to 5 are considered to be non-economic, 5 to 25 light, 25 to 100 moderate, 100 to 200 severe, and 200 or more very severe. In young shoots of summer-planted cane 0 to 50 are considered to be non-economic, 50 to 100 light, 100 to 600 moderate, 600 to 2,000 severe, and 2,000 or more very severe. (R. Mathes)

GREENBUG*

(Methods used by State and ARS Entomologists in Texas, New Mexico, Oklahoma, and Kansas)

Two greenbug surveys are usually made each year. One is made in November to determine the fall infestation and another in the latter part of February or early March to determine winter survival and the potential infestation present.

Where large small-grain acreages are present, at least 5 fields are examined in each county. Fields selected should be at least 5 miles and preferably not more than 15 miles apart. In the November survey an effort is made to select early emerged fields or fields containing volunteer plants. The exact location of the field is recorded together with any pertinent notes on crop status and development. Five samples are examined about midway along the edge of the field. Each sample area is 25 steps apart as illustrated below:



* Toxoptera graminum

Each sample consists of one linear foot of drill row. If the infestation is light (50 or less greenbugs per linear foot), an attempt is made to obtain an exact count. However, if the infestation is heavy, an estimate of the number per linear foot is made. If the heavy infestation appears to be uniform, the estimate is made by counting the number on one plant and multiplying it by the number of plants in the one-foot sample. A numerical rating of 0 to 5 is given each sample as follows:

0	None	= no greenbugs
1	Non-economical	= 1 to 10 greenbugs per linear foot
2	Light	= 11 to 50 greenbugs per linear foot
3	Threatening	= 51 to 100 greenbugs per linear foot
4	Severe	= 101 to 300 greenbugs per linear foot
5	Very Severe	= above 300 greenbugs per linear foot

The average numerical rating for the 5 samples is entered in the survey data report. The prevalence of parasites and predators is recorded in the remarks column of the survey data sheet. (R. G. Dahms).

WHITE-FRINGED BEETLES

There are two methods by which the presence of white-fringed beetles (Graphognathus spp.) can be determined: (1) inspections for adult beetles on plants and on the surface of the soil, and (2) inspections of soil samples for larvae. Effective surveys can be made by using one or a combination of these methods depending upon the season of the year. Certain definite procedures must be followed to effectuate a successful white-fringed beetle survey.

1. Likely Areas of Infestation. These are determined by possible exposure from known beetle-infested areas within the infested states as well as from infested South American countries. They include properties that have been landscaped with nursery stock moved from infested areas, railroad properties when the railroad traverses infested localities, farm crop processing plants, community centers, military installations, and other points where equipment and materials from various parts of the country are assembled, as well as ports where the insect may have been introduced.

2. Favorable Sites. After the area has been determined, it is necessary to select sites within the area to survey. On farms, the inspections are concentrated on cultivated fields, pastures, and fence rows. In residential areas, the inspections are limited to flower beds, undeveloped lots and alleyways. In industrial areas, checks are made in vegetative areas on the property and environs.

Inspection for Adults. Adult inspections may be made from late May to mid-September. The adult beetle shows strong preference for certain broad-leaf food plants such as peanuts, velvetbeans, soybeans, beggarweed, cocklebur, ragweed, blackberry, goldenrod, aster, petunias, zinnias, and chrysanthemums. By restricting the examinations to plants preferred by the beetle, better results may be expected. The finding of the characteristic feeding sign of the adult white-fringed beetle is a big asset in locating infestations. These signs are easily distinguished from injuries caused by most other insects. Search is made for semicircular cuts made in the margin of the leaf. One portion of the injury presents a smooth, slightly curved surface, whereas the other portion presents a serrated or saw-tooth edge. Upon finding characteristic feeding signs, close observation is made on the ground or in debris for the beetle. Its protective coloration and habit of the insect to feign death oftentimes make it difficult to find.

Inspection for Larvae. Larval inspection may be effectively done from early fall to late spring. This is done by selecting soil samples from around the roots of perennial plants. Although the larvae feed on several hundred species of plant, observations have shown that the preferred food plants include practically all field and garden crops and some native vegetation such as dogfennel, polypremum, evening primrose, goldenrod, ragweed, broomsedge, wild geranium, plantain, dock, and various briers. Selective digging and examination of the soil sample for the larvae should be made under preferred food plants in representative portions of the land. In the early spring when plants, both native and cultivated, begin growth, larval inspections

can be done by noting plant injury, as several food plants when attacked by white-fringed beetle larvae show certain abnormal symptoms such as yellowing, reddening, or wilting, and dead plants may be observed. These symptoms assist the inspector in further limiting the number of plants to be examined. In this type of inspection the plant is dug up by the roots with a hand trowel or shovel and the soil broken apart and examined. It is not necessary to dig large amounts of earth; the larvae, if present, will usually be found on the roots of the plant or in the soil nearby, and a majority of them will be found in the upper 3 inches of soil. (C. C. Fancher).

Prediction of Alfalfa Caterpillar* Populations
(as used in California)

Sampling methods: Samples of the larval population are taken by sweeps of a standard insect net. The lower edge of the net is held eight to ten inches into the alfalfa and as the sweeps are made, the rim of the net should be held perpendicular to the ground. The sweeps are made through a half circle from one side of the sweeper to the other. A step is taken between each sweep. Normally a circle of the field will be made taking one or two sweep samples at frequent intervals. All types of growth (height, variety, color, ridges, between ridges, "islands", etc.) should be sampled. Fields or portions of fields which grow more slowly than normal, e. g., remain in the 1/4 stage for a long time should be watched carefully. When confirmation counts (check counts made to confirm previous predictions) are made, fewer samples, generally at a few specific spots, are taken. As one becomes more experienced, most of the counts are estimated. Only about every fifth sample is counted. Twenty minutes per field, although some will take much more, is a good average. It is important to realize that slack periods occur between broods. Under conditions favorable for the caterpillar a field may go from the oviposition stage to the injurious stage in ten days or less. Routine visits are made to every field each week and such supplementary counts as seem necessary are made between visits.

Economic level of infestation: The standard by which economic infestations are judged is a sliding scale centered around 200 non-parasitized larvae per 20 sweeps of the standard net. This "center point" is to be used for average conditions (which rarely exist). Other factors, such as growth, stand, period remaining until harvest, must be taken into consideration. For example, this center point is too low for a dense vigorously growing alfalfa field and for infestations developing during cool weather.

Factors favoring damage: The development of an economic population is favored by (a) large flights of adults when the alfalfa is short, (b) few short fields in the vicinity at time of flight, (c) slow or uneven growth fo alfalfa, (d) insufficient parasites to reduce the population below the economic level, and (e) hot, dry weather. (R. F. Smith and W. W. Allen).

* (*Colias philodice eurytheme*)

Detection of Ladino Clover Seed Midge Infestations

Serious losses to Ladino clover seed production in Oregon have resulted from attacks by the Ladino clover seed midge (*Dasyneura gentneri*). This insect is a new species with its distribution largely unkown. The detecting of infestations is, therefore, of concern wherever Ladino clover is grown for seed. White and alsike clovers may also be infested by the insect.

In new clover fields infestations build up gradually and may not reach peak until the second year of seed production. The presence of midge cocoons on the soil surface under vegetation and debris is a valuable indicator of infestation past or present. Even the empty cocoons or their recognizable fragments may be in evidence for a year or two after the adults have left them. While adult or immature stages infesting clover are present only at certain times of the year, the cocoons accumulate in infested fields. The cocoons will always be sufficiently abundant to be found readily in fields which have at any time within the previous two or three years carried infestations of economic intensity. The use of cocoons to indicate

an infestation makes possible the inspection of fields for infestation at any time of year that the ground is not frozen or covered with snow. However, this method will often fail to reveal extremely light infestations such as occur in new clover plantings or those in heavily pastured clover.

The cocoons are oblong, light gray to white, slighty under 1/16 inch wide and only slightly longer. Though small, their light color makes them easily visible. They occur in greatest numbers in depressions in the ground where compacted vegetation trash has accumulated. Usually they are most abundant in the shallow irrigation trenches known as "corrugations," especially in older fields where protective layers of well compacted trash have had time to accumulate.

Detection of infestations in clover fields by sweeping with a net for the adults is rapid and convenient but the method has certain limitations. If no adults are taken in the net, it may mean that (1) there is no infestation, (2) the infestation is not in the adult stage, or (3) conditions are such that the net is not catching the adults when present. The first emergence of adults from overwintering cocoons coincides fairly closely with the appearance of bloom on the clover. In central Oregon, from early in June until the seed crop is harvested in early September, three broods of adults appear, each about a month apart. Emergence of each brood requires roughly two weeks. The emergence periods are separated by an interval of approximately two weeks during which few or no adults are present in the fields. Sweeps taken during these intervals may give a negative indication, even where heavy infestations exist. Wind causes adults to go deep into the vegetation for shelter. Net sweeps on windy days, especially in deep vegetation, may give negative results. This is likely to be the case when moderate to low adult populations are present. Adults are most abundant on the upper surfaces of the plants around midday when the sun is highest.

In sweeps repeated at intervals throughout the day in a single field those taken during the midday (11:00 a.m. to 1:00 p.m.) yielded approximately 4 times as many midges as sweeps made in the early morning (8 to 9 a.m.) or late afternoon (4 to 5 p.m.). Therefore, light infestations are most likely to show up if the sweeps are taken during the midday period.

The most reliable method of detecting Ladino clover seed midge infestations is to find the larvae in the clover heads. By picking heads in which 1/3 to 3/4 of the florets have turned down and are becoming brown, one can be assured that any mature larvae present will begin dropping out in a day or two. If the heads are placed in transparent cellophane bags they can be kept fresh for several days, and the orange-colored larvae, when they emerge, can be seen through the bags. It is best to leave several inches of stem on the heads. Then if the heads are placed in the bags stems down, the emerging larvae will fall free of the heads to the bottom of the bags. Otherwise, in their attempt to hide, the larvae may crawl back into the heads to spin their cocoons and not be detected. If the clover heads are to be taken to the laboratory, the bags are handy for keeping them fresh in transit. In the laboratory the clover stems are put in bottles of water, with the heads leaning free of the bottle mouths. Bottles containing the clover are then set in pans into which the emerging larvae drop and accumulate. By this method the clover heads can be kept fresh enough at room temperature to obtain daily larval emergence counts for 10 to 12 consecutive days. The pans can be checked at any convenient time, even days after they are set up. This method will reveal infestations too light to be evident by any of the other methods discussed. (H. W. Prescott).

LYGUS BUGS
(Methods used in California)

On alfalfa seed: Alfalfa grown for seed should be treated for lygus control only when the lygus bug population justifies it. The treatment level will vary with the growth stage of the alfalfa. The treatment levels are the numbers which indicate the proper time of insecticide applications, and are not, necessarily, the population density at which economic damage occurs. Treatments are made at these levels to avoid later populations which may cause economic damage. Lygus counts are based on two-sweep counts taken with a standard net at 10 to 20 stations over a field. At least three two-sweep counts are made at each station. The margins of the field, spots with heavy growth, and other areas of the field may have a significantly higher count than the remainder of the field. In general, all counts in a field are averaged and treatment is based on this average population. Occasionally it is practical to treat only portions of a field.

Alfalfa in the early bloom stage is treated when the lygus-bug count reaches one insect per sweep. During the period of seed set, the fields are treated when the count of lygus bugs reaches six per sweep. Counts are determined by doubling the nymphal count and adding it to the adult count. For example, two adults and two nymphs per sweep equal a count of six; four adults and one nymph also equal a count of six; and similarly, three nymphs or six adults equal a count of six. If lygus bugs have been kept under control during the period of seed set, there is seldom any need for treating the maturing field; however, if the pests appear to be unusually abundant, the count for treatment is ten per sweep, determined in the same manner as described above.

On cotton: Lygus bugs are particularly attracted to succulent or rank-growing fields. Sweeps in cotton are made through the tops of one row. An average total of ten lygus bugs per 50 such sweeps is the minimum injurious number. Each nymph is counted as two and each adult as one. The presence of nymphs indicates a more advanced and serious infestation. This is for average conditions; it is possible that a lower population that is maintained for a long period of time may cause economic damage. However, in most years the populations do not hold steadily at one level.

On blackeye beans or cowpeas: A favored oviposition site of lygus bugs infesting blackeye beans is in the developing pod and such spots are commonly seen as small depressions with the cap of the egg forming the bottom. As the season progresses so does the number of nymphs and it is not unusual to find fields in which there are more nymphs than adults. In lygus - infested blackeye bean fields it is possible to show a correlation between populations and the amount of injury at harvest time. These fields are sampled by means of a standard 15 inch net. A sweep across two rows of beans constitutes one sweep and five such sweeps are made at each of ten stations in the field. The total number of adults and nymphs are recorded separately for each series of five sweeps. A population averaging 50 or more lygus per sweep is sufficient to cause considerable damage, especially if present when beans are in a susceptible stage. A population this heavy can be tolerated until late bloom and early pod stage when the beans should be treated.

Studies have made possible the following generalities concerning abundance and resulting seed injury. A population averaging 0-10 lygus per 50 sweeps persisting from early pod time to harvest will result in from 0.4 to 2.0 percent of beans with injury; a population of from 15 to 20 will cause 2.5 to 5.0 percent seed injury; from 40-50 lygus will cause 6.0-12.0 percent injury and 60 lygus or more per 50 sweeps will result in 15 percent or more of the seed injured. (R. F. Smith and J. E. Swift, alfalfa seed; G. L. Smith, cotton; W. W. Middlekauff, cowpeas).

Technique For Making Rice Water Weevil Larval Counts

Clumps of rice containing at least five plants, together with the soil surrounding the roots, were removed by hand. All but 5 plants and the excess soil were removed and discarded. Two such samples were taken and placed in a ten-inch cylinder (with sides 12-15 inches high), constructed of sheet iron, the bottom of which was covered with 20-mesh copper screening. The cylinder was then placed in six to twelve inches of water and the roots of the rice clump shaken vigorously in the water within the cylinder, after which the clump was discarded. The larvae that are completely loosened from roots or soil by this treatment float to the surface. The floating larvae were counted and removed by means of a sieve. The cylinder was then shaken vigorously which dislodged additional larvae. These also were counted and removed. This process was continued as long as it brought additional larvae to the surface. In most cases five to eight shakings completed the count. Numerous examinations of the materials remaining in the cylinder or in the clump of rice after this procedure showed that very few larvae were missed other than extremely small larvae capable of passing through the 20-mesh screen. In taking of data two such samples were taken from each plot. (F. E. Whitehead).

STORED GRAIN INSECTS

Farm-type bins. For farm-type bins up to 5,000 bushels, samples should be taken with the standard 5-foot grain probe from 5 locations: the center, and about 1 foot from the wall at the 4 cardinal points of the bin. For shallow bins, one probe from each location is sufficient. If the grain is deeper, from 2 to 3 probes must be taken from each location using extensions on the probe so that samples can be taken from a vertical column from the surface to the bottom of the bin; e. g., if the grain is 10 feet deep a sample from the top and bottom 5 feet is sufficient, but if the grain is 15 feet deep it will be necessary to take samples from the bottom, middle, and top five feet of grain. It should be noted that in the sampling of round metal bins it may be difficult to take the samples from the 4 quadrants when the bin is over-filled. In such cases the probes should be inserted in a slanting position so that the bottom samples will be taken from the outside portion of the bins.

Quonset huts. In the sampling of quonset huts or large, rectangular wooden bins additional samples are necessary, the number depending upon the size of the building and the depth of the grain. For the average quonset 100' x 40', samples are taken at 12 locations approximately 15 feet apart in two longitudinal rows evenly spaced between the two side walls. If the grain is approximately 10 feet deep, samples should be taken from the top and bottom 5 feet at each location. In addition a surface sample should be taken from the center of the front and rear half of the quonset.

Elevator bins. The sampling of grain in elevator bins is complicated by the depth of the grain and the difficulty of reaching the surface of the grain from the head house floor. Unless special equipment is available to take probe samples from the top of the bin, or the elevator is equipped with an automatic sampler, the simplest method is to run the entire bin and take samples periodically from the grain stream with a "pelican" sampler. This method takes considerable time and is not always feasible. Since infestation in elevator bins is most frequently found in the grain at the surface and the bottom of bins, the following method has been adopted for routine examinations. A surface sample is taken from each bin by lowering an automatic sampling device on a rope to the grain level from the top of each bin. This device consists of a cylindrical container, the two halves of which are held open by springs. On contact with the grain, the two halves snap shut and capture approximately a gallon of grain. A sample from the bottom of the bin is obtained by running the bin for 1 or 2 minutes during which period 5 passes are made through the falling grain stream with a pelican grain sampler.

Composite sample. All probe samples for any one bin, quonset or elevator bin, are combined into a composite lot which is then cut down to a 1000-gram sample with a Boerner Grain Divider. The sample can be then sifted and the insects counted. The insects are classified as weevils or bran beetles. Rice weevil, granary weevil, and lesser grain borer are classed as weevils and all other beetles as bran beetles. (Stored Product Insect Section, Manhattan, Kansas).

A Technique for a Rapid Determination of European Red Mite Populations on Foliage

The time required for determining European red mite (*Metatetranychus ulmi*) populations is one of the most important limiting factors in carrying out field tests for the control of this pest. Since populations are subject to rapid fluctuations due to tremendous reproductive capacity, weather conditions, and intermingling of late broods, it is desirable to make population determinations for any given series of tests during as short a period of time as possible.

This report is a discussion of a technique used at the Dow Agricultural Chemical Research Field Station at South Haven, Michigan, since 1942. This discussion deals with studies made on mite populations on apple, cherry, prune, plum, peach and other foliage.

Determination of Mite Populations

Sampling: A more accurate appraisal of the effectiveness of mite treatments may be made if the mite population of each plot immediately preceding application is known. Such information is important for the checks as well as for those that are to be treated. This is desirable since large differences often exist between populations in the various plots within a planting.

The pre-treatment and post-treatment population determinations are made from samples of 50 leaves from 2 to 5 trees in each plot. The number of leaves taken from each tree is determined by the number of count trees in the plot. For example, if 5 trees are used, they are marked and ten leaves are taken from each tree at each collection. If 3 trees are used 16 leaves are taken from one tree and 17 from each of the other two. The leaves are all taken by the collector circling the tree and picking the samples at regular intervals so that a complete cirlce is made while sampling each tree. Leaves are taken from wood with a diameter of 3/4 to 1 inch and usually at arm's length from the perifery of the trees. In the case of heavily infested trees it is necessary to make leaf collections near the tips of branche as the mites move out. These leaves are dropped immediately into small containers in a "lethal chamber" shown in Figure 1. All leaves from a plot are put into one receptacle. This receptacle may be of any suitable size. One quart cylindrical paper ice cream containers have proved satisfactory, although slightly larger containers may be more suitable when the leaves are very large such as are sometimes encountered on Duchess, Baldwin, Greening, and other varieties. An identifying card is placed on the leaves in the receptacle.

Killing the Mites: Difficulty is sometimes encountered while making population counts of live mites. When the leaves are heavily populated and when counts are made at high temperature, the active forms move about rapidly, many running off the leaves or shifting from one side of the leaf to the other. These difficulties have been overcome by placing the leaf samples immediately into the small containers which are carried in the "lethal chamber" mentioned above. The chamber is simply a tight container of a size suitable for carrying about the orchard. (Figure 1). It is constructed of a wooden frame covered with pressed wood. A 2-3/4" opening is cut in the cover over each container. These holes are snugly fitted with plugs which are merely lifted and replaced each time a leaf is dropped into the receptacle. An interior view of the lethal chamber is shown in Figure 2. On the lower surface of the chamber lid, provision is made for use of the lethal chemical. In the case illustrated, this consits of fastening to the lid strips of absorbent cotton wrapped with cloth to prevent fraying. Excellent results for quick kill of the active mites have been obtained by the use of propylene or ethylene dichloride. One application of a few ml. of the liquid toxicant per cubic foot of space is sufficient to give quick killing during the time required to collect fifty leaves from each of six plots. Ethylene and propylene dichloride serve very well for this purpose since they are relatively safe to the collector when used out of doors, and also indoors by observing reasonable precautions. The liquid should be charged into the cotton often enough to cause discoloration of the leaves within 20 minutes. To further insure kill of the mites the sample filled receptacles may be stored in larger lethal chambers. (Figure 3). A larger number of plots may be sampled in this way within a few hours. The samples may be stored in the receptacles in a cool moderately humid place (60-80% relative humidity) or the mites may be removed from the leaves and stored on the glass plates in a similar place until counts are made. Counts should be made as soon as possible, however.

Preparing for and Making Actual Counts: After the leaf samples have been collected, the mites killed and taken to a central station, the next step is to remove the mites from the leaves. This is done with a machine developed by C. F. Henderson of the U. S. Department of Agriculture working with the citrus mite (Metatetranychus citri) in California. The details of this machine and its operation are discussed in U. S. D. A. Circular 671, 1943. The method of operation was very similar to that described by Henderson. For the purpose of this report pertinent items and slight alterations in procedure are briefly discussed. The machine (Figure 4) consists essentially of two three-quarter inch rotary brushes, four inches long, mounted close together in a horizontal position and above a metal turn table. The brushes found most satisfactory for use on mites are of goat's hair. The brushes and turn table are operated by a small electric motor. The motor in this case is described as follows: H. P. 1/175, volts 115, cycles 60, amps 38 and rpm 1500. A 6-volt motor may be used if it is desired to use the equipment in the field where the motor can be powered from a storage battery. The turn table on the brushing machine is a metal plate which holds a glass disc of the proper size. During the brushing process the leaf samples are inserted

Figure 1. Details of collection chamber lid with one plug removed.

Figure 2. View of interior of collection chamber with samples from six plots in the six cardboard receptacles. Strips of absorbent material for fumigation may be enclosed in window screening to avoid fraying.

Figure 3. Chamber for transporting samples and for further fumigation and storage if necessary.

Figure 4. Brushing machine with leaf being inserted between brushes.

Figure 5. Equipment used for making counts. The tallies are mounted on the table top and manipulated by pressing, with the knees, levers under the table which are connected to the tally levers by strings.

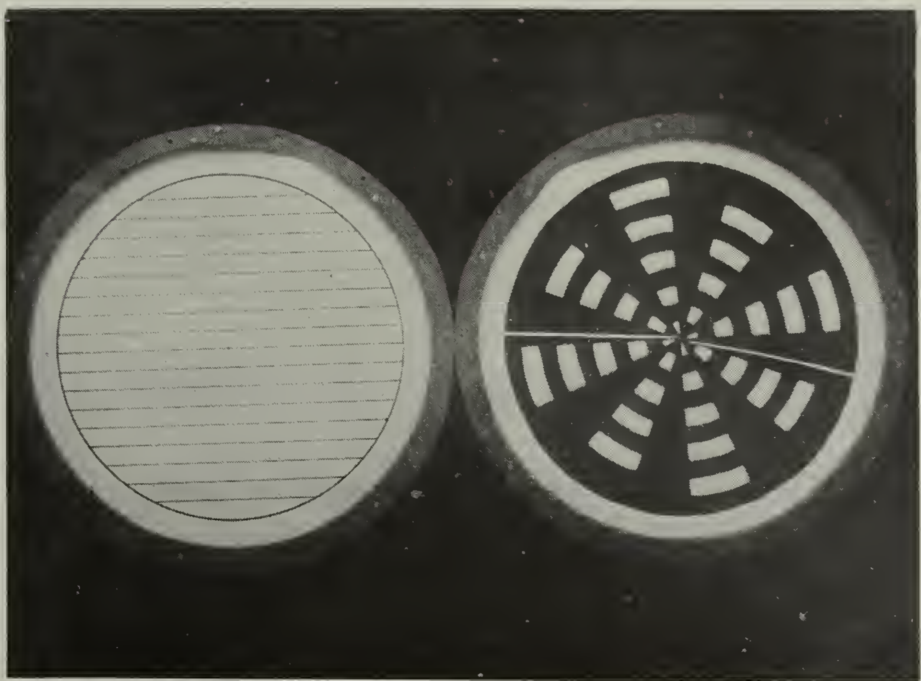


Figure 6. Holding board for easy manipulation of glass discs containing specimens. Left, parallel areas for inspection in case of light infestation. Right, white areas for inspection in case of heavy infestation.

between the rotating brushes and the mites and the eggs are dislodged. Two metal shields extend from slightly above the top of the brushes, downward to the glass disc on the turn table. These shields serve to confine the falling mites to the disc below. For maximum removal of mites, it has been found advisable to insert one end of the leaf between the brushes, withdraw it, and then insert the other end. If removal of all the eggs is desired, further brushing may be necessary after the leaf has been folded to fully expose the midrib. The glass disc placed on the turn table during the brushing process should have a diameter 1/4 - 1/2 in. greater than that of the area within the shields. This will permit handling the glass without crushing the forms collected thereon. Immediately before placing the glass disc on the turn table the upper surface should be lightly coated with thin varnish or some other suitable adhesive. The falling mites and eggs will lodge and remain on this film during subsequent handling. The rotation of the disc during the brushing process insures a fairly uniform distribution of the mites and eggs over the coated surface.

The regular laboratory equipment plus a few easily made accessories are all that is needed to make the counts. (Figures 5 and 6). The glass disc containing the mites and/ or eggs is placed on a holding board which facilitates manipulations of the disc when put into position for examination with a binocular microscope. In making the counts, one of two means of guiding the observer during the counting is used, depending upon the abundance of specimens on the disc. If only a few are encountered, the holding board with parallel fields as shown on the left in Figure 6 is used and all specimens are counted. If there are many mites, the holding board with the black and white cardboard disc as shown on the right in Figure 6 is used and only those which lie over the white areas are counted. The narrow white stripes are for guides only and mites lying over them are not counted. The total white area is 25 percent of the toal specimen bearing area. (Henderson 1.) Thus the number of forms counted in this way, multiplied by 4 gives a figure approximately the same as if the entire area is counted. When making the counts one light source, namely a microscope lamp with the light beam directed to the field of observation has proved adequate. This is different and somewhat simpler than the illumination described by Henderson. It may be that certain conditions, not yet encountered in this work, will require the setup described by him.

Enough time is allowed between the application of control treatment and leaf sampling to cause the treatment-killed mites to dry and shrivel. The first sampling after treatment is usually 3 to 5 days. If heavy rains occur during this interval many of the dead mites will be washed from the leaves. If properly handled, as described earlier, the mites which escaped the treatment, but which were killed in the lethal chamber will remain plump and may be easily identified as "live mites". Only live mites are counted.

After the counts are made the glass discs may be cleaned by immersing in a strong solution of trisodium phosphate, after which they may be rinsed in water, dried and used again. (O. A. Hammer)

LITERATURE CITED:

(1) Henderson, C. F. and McBurnie, H. V. 1943. Sampling Technique for determining populations of the Citrus Red Mite and its Predators. U. S. Dept. Agr. Circ. 671.

Determining Apple Maggot* Fly Emergence

In late August and early September infested apples are placed in a large box having a 1/4 inch mesh wire bottom and raised 10 or 12 inches on corner legs. Under the box a tray with 1-1/2 to 2 inch sides collects the maggots when they complete larval feeding in the apple and drop. Daily and sometimes twice daily the maggots are collected, counted and distributed among the soil boxes. Soil boxes are 1-1/2 x 3 feet (Size is not important) with sides 8 to 10 inches high. They are filled with 6 to 8 inches of good porous soil. Maggots are distributed among the boxes each day rather than putting each day's collection in one of the boxes. The usual number of maggots in each box is 300 or 400. When gathering the maggots from the tray, all prepupae and pupae are discarded and the soil boxes are checked frequently to remove any specimens which fail to enter the soil normally. In late fall the infested soil boxes are placed in or near the orchard and buried even with soil surface. They may be covered with wire or brush to protect them from interference by dogs or other animals. In early June cages are placed over the soil boxes to collect the flies when they

emerge. These cages are about 3 feet in each dimension covered with screen wire on at least two sides and cloth sheeting on the top and other sides. The front is attached on two edges with thumb tacks so that it can be folded back to reach in to collect and count the flies. During the emergence season the flies are collected daily. Winter mortality in these cages has ranged from 40 to 60 percent and progressive emergence estimates are based on a 50 percent natural mortality. (W. D. Whitcomb).

Technique in Jarring for Plum Curculio[1]

Jarring trees to obtain plum curculio (Conotrachelus nenuphar) adults is an old and well established practice. It was considered at one time as a valuable supplementary control measure for plum curculio on peaches. Although no longer practiced as a control measure, it is still considered a valuable tool particularly in research. Jarring is useful as a means of timing spray applications and for locating areas of heavy infestation. It may also be used as a criterion for evaluating effectiveness of spray applications.

Equipment and technique for jarring are described in this paper. The method described has been used with satisfactory results during 1949 and 1950 in the peach belts in the Arkansas River Valley centered around Clarksville and in the southwestern belt near Nashville.

The sheet used in experiments in Arkansas is 4 feet by 7 feet and is attached to a light wooden frame. The frame is hinged for folding to facilitate transporting from one orchard to another. Other equipment includes a light rubber covered mallet and a small bottle fitted with a slit rubber top for collecting the beetles.

The procedure involved in using the small jarring sheet is to hold the sheet in one hand and to jar limbs by one or two sharp blows with the mallet. No attempt is made to jar an entire tree. The beetles are usually collected at the end of the jarring period. If, due to high temperature, the beetles become active, they are captured and counted immediately. The unit of measurement of curculio abundance is based on the amount of time spent jarring. In most cases a period of 5 minutes is used. If a complete record in an area is desired, four units of 5 minutes each are taken. Usually the limbs on one side of a tree are jarred and the operator then moves on to the next tree.

The principal disadvantage in using a small sheet to jar for 5 minute periods seems to be that it has been customary to think of curculio populations as the number per tree. Since this number is an arbitrary figure and is at best only an approximation, a different unit of expressing density of population should be equally satisfactory. The number of limbs jarred in 5 minutes by different individuals will undoubtedly vary somewhat, but this variation should not be nearly so great as the differences between individual trees.

In the past jarring records have been on the basis of the number of curculios obtained per tree. This system has numerous disadvantages. The size of trees varies greatly from one orchard to another because of differences in age and growing conditions. Curculio population varies greatly among trees of fairly uniform size. This necessitates a large sample to obtain representative data. It is difficult to jar an entire tree especially if it is a large one. Unless considerable labor is available the sheets must be placed on the ground. Uneven terrain and weed growth make this impractical in many orchards.

During the summer the temperature is too high in Arkansas for satisfactory jarring during most of the daylight hours. The beetles are more active and many of them fly upon being disturbed. More records can be taken during that period of the day when conditions are favorable if the small sheet is used to jar individual limbs rather than jarring entire trees. Also the small sheet can be held close to the limbs where the curculios are located. Fewer beetles will fly before hitting a sheet held close to the limbs than one on the ground. Also more beetles can be recovered from the sheet on a rigid frame since they can be removed more quickly from it than from large sheets. Thus jarring can be done with the small sheet when high temperature would make the use of large sheets on the ground impractical.

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1 Research paper No. 1021, Journal Series, Univ. of Ark. Published with permission of director of Ark. Agric. Exp. Station.

Sheets sufficiently large to cover the area under a large peach tree require several persons to hold them. The only alternative is to place them on the ground. In many Arkansas orchards the terrain is too rough to place the sheets on the ground satisfactorily. With the sheets on the ground it is difficult to jar the tree without walking on the sheets. If they are placed on bare ground they soon become soiled making it difficult to locate the curculios on them. The small sheet on a frame eliminates these difficulties. The advantages of considering the number of curculios jarred in a 5-minute period using a small sheet on a rigid frame as the unit of measurement, may be summarized as follows: Only one person is needed to take the records. More records can be taken in the same time. Difficulties due to variations in tree size, uneveness of terrain, and high temperature are decreased or eliminated. (W. D. Wylie).

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WESTERN GRAPE LEAF SKELETONIZER

For the past several years the Bureau of Entomology in the California Department of Agriculture has been engaged in an intensive campaign directed against the western grape leaf skeletonizer (Harrisina brillians) which is restricted in occurrence to the most southern county in the State. This insect, which is a day-flying moth, is found on wild and domestic grape in the southern and eastern portions of San Diego County in a wide range of climatic niches ranging from coastal plains to desert canyons and at elevations from sea level to 4500 feet.

Visual inspection has been found to be the only acceptable method of survey. Extensive bait trap studies have been conducted in search for an attractant which would satisfactorily supplement visual inspection, but nothing of outstanding effectiveness so far tested has been found. The most promising of these tests has involved a preparation made through the addition of the abdominal tips of virgin female moths to benzene. This has shown an attraction to males but has not yet been developed to the point where it can be used on a practical basis.

In the matter of visual survey, the presence of adults is most easily observed. They have a wing expanse of approximately one inch and have an iridescent blue-black metallic color. They usually emerge from over-wintering pupae sometime soon after April 15, and are again abundant in July and to a lesser degree in September based on two, and a light third, generations annually. If present and forced into flight they are inclined to flutter around and return to the vine from which they were originally disturbed. Adults are inclined to favor the lower portion of the vines, both wild and cultivated, and it is on these lower levels that inspection is concentrated. Actually, the adults are very retiring and tend to drop rather than fly when disturbed, making detection somewhat difficult in the absence of heavy populations.

The lemon-yellow elliptical eggs are generally deposited on the under surface of the leaf. They are laid on end, slightly separated, in more or less irregular rows making up patches of from twenty to one hundred eggs. They are not greatly dissimilar from those deposited by the smaller more common lady beetles. Their presence can be easily overlooked unless a leaf by leaf inspection is being made.

The characteristic feeding damage of the gregarious larvae is very conspicuous and easily noted on badly infested canes at a distance of one to two hundred feet.

Larval feeding up to the 4th instar is carried out on the under surface of the leaves producing an extremely thin tissue paper-like area, white and translucent when fresh, later turning brownish. As the larvae mature, the leaf surface is completely eaten. The earlier larval instars are conspicuous due to their feeding as a colony, side by side, in a steadily advancing line. The mature larvae are also conspicuous due to their brilliant blue and yellow lateral rings which relatively alternate over the length of the body. On severely infested vines nothing remains but the canes, fruit, leaf petioles and the major portion of the midrib.

The mature larvae pupate under the rough bark of infested vines, usually close to the ground level and even in the grass roots several inches away from the base of the vine. The pupae are relatively flat, yellow to dark brown in color depending on age, and encased in a white opaque cocoon. Inspection for pupae even during the dormant period is generally deemed impractical due to the time element involved.

Project experience has been that initial infestation is usually found in the border rows in vineyards. The original hour-glass pattern of inspection was for that reason subsequently changed to a peripheral survey including the first five to ten rows in vineyards in areas suspected of infestation. Although as might be expected there is considerable overlapping during the active season, the various stages closely follow the normal pattern in relation to the generations discussed under adults. (A. G. Forbes, California Dept. of Agri.)

CHERRY FRUIT FLY

Three methods of detecting cherry fruit fly (Rhagoletis cingulata) infestations are currently being used in Siskiyou County, California.

Detection of Adults: This phase is accomplished by trapping, using a sticky-sided carton baited with ammonium carbonate. Quart-size Sealright Thermorex paper containers are used with the inner surfaces coated with Mapco Stickem Special. The trap is attached to a tree with a wire that extends through the bottom and has a small hook on the inside on which the bait packet is hung. Approximately two ounces of powdered ammonium carbonate is sealed into two inch square plastic packets. The packets remain sealed until time of use (when 10-12 perforations are made in them) and are replaced in the traps at weekly intervals. Traps are placed, when convenient, at a height of about eight feet above the ground on southeast side of the tree. Traps are generally replaced once or twice during the three months' trapping season.

Detection of Larvae: Accomplished by processing fruit samples. One pound samples of cherries are crushed by running them through an old-fashioned hand-operated clothes wringer with rollers grooved and set apart so as not to crush pits. The crushed fruit is placed over 1/4 inch mesh screen in hot water, pre-heated to 140° - 160° F., for at least one minute, the fruit is then discarded. The pulpy water remaining, containing the larvae if any, is placed in a pan in a swirling device propelled by a small electric motor. Rotation speed is controlled by a rheostat. In the swirling water larvae and other heavier particles gravitate to the center of the pan where the greatly reduced level of water permits easy detection.

Detection of Pupae: This is accomplished through soil sifting. Soil within the drip line of the tree is sifted through mesh screen (6 wires per inch) to eliminate large particles then resifted through a smaller screen (14 wires per inch) to eliminate fine soil. The remainder is inspected visually for puparia. This method of detection has been used primarily to confirm infestation on properties where adults were taken in traps but no larvae found in fruit samples processed. (D. W. Robinson).

MEXICAN FRUIT FLY

There are two methods used to determine the presence of Mexican fruit flies (Anastrepha ludens) in the citrus orchards of the Regulated Area of Texas. One of these is the operation of traps for the purpose of measuring the adult fruit fly population. The other is grove inspection for the purpose of determining whether or not the fruit is infested. Traps are also useful in determining when the first infested fruit will be found, as this can be very closely estimated after the first gravid female is trapped.

The traps are of the glass flask type, using liquid bait, with an opening through the bottom to permit entrance of the flies. These traps are hung in the citrus trees, four or five feet above the ground and well into the center of the trees. The bait used is brown sugar and water. One and two-tenths pounds of sugar to a gallon of water is an effective mixture. Two gallons of bait is sufficient to fill twenty traps. They are placed in selected orchards scattered over the various districts, insuring a complete coverage over the entire Regulated Area. The most healthy groves are selected in which to place the traps. Trees with heavy foliage are most desirable for trapping, since the adult fruit fly prefers the shade to sunlight. The traps are usually set twenty to an orchard and are arranged in a rectangular pattern. They are placed in two rows, usually beginning with the outside row of the grove and are spaced one trap to every third tree in the row. The best arrangement is to place eight traps in a row, with two traps across the ends and another eight traps down an inside row, forming a perfect rectangle. The traps are inspected once each week, at which time they are cleaned and rebaited. One inspector can operate two hundred traps a day. Trap operations normally begin in the early fall and continue until late spring or at such a time as larval infestations are found generally over the entire Regulated Area.

Grove inspections are made for the purpose of determining whether or not larval infestations are present in the fruit. The result of these inspections governs the movement of the fruit from the groves to non-infested area. If the fruit is free of infestation of the Mexican fruit fly, it can move through regular channels without further treatment. In case larvae are found, the fruit must be sterilized before shipment to free areas. The most satisfactory method of grove inspection is to take one or two rows at a time and work from one side of the grove to the other until all the trees have been checked. The inspector examines fruit on the ground in looking for larval infestations. It is not possible to examine all the fruit which might be on the ground as there are other factors, such as, cultivation, winds, mechanical injury and disease, which cause fruit to drop. It is necessary, therefore, for the inspector to know what fruit to eliminate in his inspections. The trained or experienced inspector is able to distinguish, in almost every instance, infested fruit from those which have fallen from these other causes. The fruit fly lays its egg in the fruit while it is still on the tree. The eggs hatch into small worms which begin working inside the fruit and cause considerable internal damage. It also takes on a discoloration on the outside which is quite helpful to the trained eye in finding infested fruit. For instance, the light yellow color of a normal grapefruit changes into dark amber color, or somewhat more of an orange color. Early-season inspections are usually confined to grapefruit since it is the most preferred host and, as a rule, the first infestations are always found in this type of citrus. The simplest and quickest procedure to determine whether or not the fruit is infested is to clip both the stem and blossom ends with a sharp knife, avoiding cutting deep enough to rupture the juice cells. If an infestation is present in its early stage, small shotlike holes having the appearance of having been drilled and brownish threadlike tunnels are quite noticeable in the rag of the fruit. If it is an advanced stage there will be unmistakable internal evidence, such as the breaking down of the juice cells and a complete honeycomb condition showing in one or both ends. Fruit from infested groves is required to receive the vapor-heat (a heated mixture of saturated vapor, air and fine water mist) treatment before moving to non-infested areas. Grove inspections are continued until such time as a general infestation is found throughout the Regulated Area. Whenever the infestations build up to a point where a majority of the groves are found infested, grove inspections are discontinued, and the entire Area is declared an infested zone. All fruit shipped from the Regulated Area for the remainder of the season is required to be sterilized by the vapor-heat method before moving to non-infested areas and inspectors devote full-time to the supervision of this process. (B. C. Stephenson).

JAPANESE BEETLE

(Methods used by the Japanese Beetle Laboratory, Entomology Research Branch)

The presence of the Japanese beetle (Popillia japonica) in an area can be detected by placing bait traps at suitable sites during the period of flight of the adults. The density of the population can be estimated by observing the extent of feeding by the adults on favored food plants and by the examination of soil at selected sites to determine the number of grubs present.

Traps are of value in determining the presence of beetles in areas remote from the generally infested region. In these areas traps attract and capture beetles even when a diligent search often fails to reveal their presence. Beetles are drawn from the leeward to a trap by means of an attractant. Most of those captured fly into the superstructure of the trap and fall into a receptacle from which they can not escape. The trap consists of a four-winged baffle mounted on top of a funnel, a device for holding the dispenser of the attractant, and a receptacle for holding captured beetles, and is painted a high luster yellow. The attractant is a 10:1 mixture of technical geraniol and U. S. P. eugenol by volume or a 9:1 mixture of technical anethole and U. S. P. eugenol by volume and is dispensed by means of a bottle and wick. The details with reference to the trap are given in U. S. D. A. Circular 594. The best results are obtained when a trap is hung on a rod or other suitable support in a sunny location so that it is 4 to 5 feet above the ground and to the windward of plants most subject to attack. It should not be closer than 10 to 25 feet to plants on the leeward. If located so that the odor of the attractant is carried across an open field, a trap may attract beetles from a distance of 500 yards. When trees, buildings and other obstacles deflect and impede the movement of air, the zone of attraction is reduced considerably. When a trap is favorably placed, it can be expected to capture about three-fourths of the beetles attracted to it.

The density of the adult population in an area can be estimated when the beetles are present in the greatest numbers or when the injury by feeding is the most noticeable. The tree hosts most useful in estimating feeding damage are elm, horsechestnut, linden, Lombardy poplar, Norway maple, planetree, white birch, willow, apple, cherry, peach, and plum. The low-growing plants and vines most useful for this purpose are elder, grape, sassafras, smartweed, and Virginia creeper or woodbine. Althea, dahlia, rose, and zinnia are often good indicators, and asparagus, alfalfa, clover, corn, and soybeans are sometimes useful when examining fields and gardens. In some areas other plants may be used in estimating the feeding; a complete list of the food plants of the beetle is given in U. S. D. A. Circular 547. The lacy appearance of the damaged leaves on most plants within the infested area may be attributed to feeding by the Japanese beetle, but the foliage on representative plants should be carefully examined to determine that the injury was caused by the beetle. Of course, estimates of feeding should not be made on plants that have been sprayed or dusted with an insecticide. Usually in making a survey of an area, observations are made from a car driven slowly along the roads, and the extent of feeding is recorded at various points on a map according to the following numerical system:

(1) Very severe. Over 50 percent of the host trees entirely brown from beetle feeding; vine hosts completely defoliated.

(2) Severe. From 25 percent to 50 percent of tree hosts mostly brown; nearly all vines defoliated.

(3) Moderately severe. From 10 percent to 25 percent of tree hosts brown; heavy feeding on vines.

(4) Moderate. Less than 10 percent of host trees partly brown; moderate feeding on vines.

(5) Light. Tree hosts not showing brown though there may be evidence of light feeding on close examination; light feeding on vines apparent from a short distance.

(6) Very light. Occasional light feeding that is apparent only on close examination. The beetles or eaten leaves are located only after a search.

With the symbols indicating the extent of feeding on the map, it is then possible to make a general estimate of the density of the Japanese beetle population in the area.

The examination of soil for the immature stages of the beetle is usually limited to a specific lawn, golf course, park or pasture, and is conducted to determine whether the injury to the grass is caused by the grubs feeding on the roots and to determine the density of the population in the soil. Many areas of turf in the eastern part of the United States have been ruined by these grubs. In making the examination, a square foot of sod is removed to a depth of 3 or 4 inches and placed in a large tray or other suitablecontainer. The soil is removed from the roots and examined carefully to determine the number of grubs present. The procedure is repeated at other spots until a sufficient area has been examined to establish approximately the severity of the infestation. Usually 12 or 15 spots are enough to obtain a general estimate of the density of the population in a suburban lawn. (W. E. Fleming).

GOLDEN NEMATODE

Survey inspections to detect the presence of golden nematode (Heterodera rostochiensis) cysts may be accomplished by field soil surveys, grader debris examination, and plant root examination.

Field survey consists of systematically collecting about six pounds of soil per acre. About a tablespoonful of soil is picked up with a pointing trowel at intervals of eight paces following a grid pattern. The soil is collected in a No. 12 wet-strength double-thickness paper bag, which is numbered to show location of the sample within the field and also labeled to identify the field. A sketch is made of the field showing the areas represented by each sample. The tops of the bags containing the soil are carefully folded and sealed with paper adhesive tape, to prevent leakage, and stored until processed in the laboratory. When a field or portion of a field is under suspicion or shows symptoms of infestation, it is advisable to inspect it intensively. This is accomplished by dividing the field into smaller blocks and collecting samples at intervals of four or two paces, in which case four or sixteen times as much soil is obtained per acre by the eight pace method. Field survey work can be performed at times when the ground is not frozen, too wet, or when crops do not interfere.

Grader sampling consists of the collection of soil that has accumlated under the potato grader, under the loading belt, in the storage bin, or in any location where potatoes are concentrated in quantities. It is found generally that such debris has a high content of potato vines, sticks, stones, potato skins, and other extraneous offal. Care is taken to exclude this type of debris, in other words, as much soil as possible is secured. In cases where large quantities of soil are available, it is desirable to obtain two or more samples. Each bag is filled to a depth of four to five inches and the top folded and sealed with tape. The bags are given a collection and sample number which will clearly indicate the location of the grader or storage house and date collection was made.

Following the collection, the soil samples are processed in the laboratory by a soil washing method to determine the presence or absence of golden nematode cysts.

The method of examining potato roots may be used to advantage under certain conditions. Fields are looked over carefully and patches showing plants with weak spindly stems and stunted tops are selected. Examinations also are made around buildings or where grader debris has been disposed of on fields. The plants are carefully removed from the soil and the roots examined for cysts. A 10X hand lens is helpful. The work is limited to a period of about two weeks when the swollen female has emerged, but has not become detached from the root. The cysts can be seen about the time blooms appear on the potato plants.

In consideration of the characteristics and potentialities of dissemination, every reasonable precaution should be taken to prevent the spread of this organism. Vehicles assigned to survey should not be permitted to enter any property. They should remain on paved highways or recognized thoroughfares. Trowels must be free of soil collecting recesses and grooves, and brushes should be provided for the cleaning of inspectors' shoes after leaving fields or potato storage houses. It is advisable for inspectors to wear trousers free of cuffs. Vehicles used on survey must be cleaned periodically by washing and should be kept free of soil at all times. Vehicles used in connection with infested properties must be steam cleaned prior to use on non-infested lands.

Further details on the survey and soil processing methods are contained in "Manual of Survey and Laboratory Methods Used by Golden Nematode Control," a copy of which may be obtained by writing to the Golden Nematode Control Project, P. O. Box 96, Hicksville, L. I., New York. (J. F. Spears).

SWEETPOTATO WEEVIL

Surveys are made to determine the presence and extent of sweetpotato weevil (Cylas formicarius elegantulus) infestations. The methods consist of visual inspection of sweetpotatoes that are usually found in one or more of the following locations:

1. Post harvest crop remnants, including crowns and vines, left in fields.

2. Storages, packing sheds and processing plants

3. Plant beds and mother rows after abandonment by growers.

Primary inspection consists of the examination of the surface of sweetpotatoes for weevil emergence holes, egg, and feeding punctures, and if found, potatoes are dissected for possible recovery of specimens,of which immature stages predominate. The effectiveness of inspection in relation to location may be considered as 1, 2, 3, as listed above, but weevil population abundance usually occurs about October in the principal sweetpotato growing states. (M. S. Yeomans).

TOMATO FRUITWORM

Surveys are conducted weekly from late June to late August in the tomato-growing areas of Utah to determine the expected populations of tomato fruitworm (Heliothis armigera). Eight samples, each sample containing 25 compound leaves, are taken at random in each of two fields in the various tomato-growing localities. A total of sixteen to twenty fields over the entire tomato-growing area are surveyed. Each sample is taken by beginning either at the top or the bottom of a branch and examining both sides of all the leaves for tomato fruitworm eggs. Leaves containing eggs are removed from the plants and the eggs examined under a hand lens to determine definitely if they are tomato fruitworm eggs. The number of fruitworm eggs is then recorded per one hundred leaves. With this information as a basis the average number of eggs perone hundred leaves is estimated for the entire tomato-growing area each week.

It has been determined in Utah that the presence of an average of one egg per one hundred leaves anytime during the period of fruit setting will result in 2 to 5 percent wormy tomatoes, which is sufficient to justify control measures. (W. E. Peay).

ONION THRIPS*

The following method 1/ is used at the Twin Falls, Idaho, laboratory of the Truck Crops and Garden Insects Section for the determination of thrips populations on onions in experimental plots:
*(Thrips tabaci)

1/ Shirck, F. H. Collecting and Counting Onion Thrips from Samples of Vegetation. Jour. of Econ. Ent. 41:(1) 121-123.

Samples of onion plants are gathered and enclosed in cardboard tubes having an inside diameter of 5-1/8 inches and a height of 7 inches. The tube has a cloth top glued in place and is provided with a slip-on metal cover to close the open end. The individual sample consists of 10 onion plants, which are cut off just above the ground. The plants are placed in the tube with the butt ends against the cloth top, and the portions of the leaves projecting beyond the cylinder are cut off squarely. If thrips populations are being determined from onion seedheads, a sample of five heads is used and the same procedure followed as for onion plants. Separation of the thrips from the sample is accomplished by drying it at 115° F. for 24 hours. Before drying, the slip-on lid is replaced by a metal funnel having a 1-inch vertical band around its top to provide a close fit with the cardboard tube. The funnel is attached through a cork to a small jar containing a 0.5-percent solution of formalin. After exposure to the 115° temperature, the thrips leave the sample and fall into the formalin solution, from which they are later strained and counted. The formalin acts as a preservative to prevent the thrips from attack by molds in case the counting is delayed. The strainer, which also serves as a counting device, consists of a piece of black cloth cemented to a metal ring of convenient size to be used under binoculars. Guide lines 3/8 inch apart are stitched on the black cloth with white thread. Before beginning the counts, the black cloth is pressed firmly on an absorbent cloth to draw out the excess moisture remaining in the cloth. In field experiments one sample of 10 plants, or 5 seedheads, per plot has been used to evaluate the results of control applications. (F. H. Shirck)

WIREWORMS

A survey method for determining wireworm (Elateridae) populations as a basis for biological and control studies has been developed for the irrigated lands of the Pacific Coast States. This method in modified form could be used to determine almost any wireworm population wherever the wireworms can be separated from the soil by screening. It can also be used by farmers to determine how many wireworms are present in a field before planting, and thus serve as a guide in avoiding damage to susceptible crops or indicating the necessity of using soil insecticides to reduce the infestation.

A simple portable soil sifter 1/ can be made from a piece of 1/4 inch spring steel about 36 inches long, with a quarter twist near the base, and fastened into the long arm of a T-shaped base of 2x6 inch wood plank. A suitable cross arm of same steel with a bend in the ends is welded to the top of the upright to hold screen frames. Frames can be about 24 inches square made from 3/4 x 3 inch wood, with ordinary hardware screen (4-mesh) or window screen (12-mesh) tacked on tightly.

The method in brief comprises the digging of at least 20 random test holes per plot, or per acre, with a 6-inch post hole digger to a depth of one foot. The soil from the 20 test holes, collected in pails, is passed through the coarse 4-mesh screen onto the 12-mesh screen where the shiny yellow wireworms are readily separated, counted, and kept for species identification.

The data can be arranged in the following classification for comparative purposes, based on the potential damage that wireworms can do to field and truck crops:

Infestation or Damage	No. of wireworms per 20 post-holes	No. of wireworms per cu. ft. (approx.)	Rating
Non-economic	0	0	0
Light	1-3	Less than 1	1
Moderate	4-8	1	2
Heavy	9-19	2	3
Severe	20 or more	4 or more	4

The above infestations would apply to a number of row crops, such as sugar beets, beans, peas, carrots, onions, lettuce and grains. In case of hill crops, such as corn, melons and potatoes, these infestations would cause more damage because of the wireworms concentrating in the hills. This is especially true of potatoes where the tubers stay in the ground for a longer time subject to feeding by wireworms. Sometimes even though a zero population is indicated by this method there may be considerable damage to harvested tubers. If any wireworms are suspected to be present in a field, it should be avoided for the growing of potatoes or else treated to kill the wireworms first.

Methods of sampling soil for wireworms are also described by Jones 2/. (Truck Crop and Garden Insects Section).

BEET LEAFHOPPER

Spring surveys are made annually, generally during April, to determine the abundance and distribution of overwintered beet leafhoppers (Circulifer tenellus) and their principal wild host plants in representative spring breeding areas in southern Idaho and eastern Oregon. To measure leafhopper abundance, 50 samples are taken at random at 3-mile intervals along the routes traveled where wild host plants occur. The counts are made with the Hills' 3/ square-foot sampler, which traps the insects in a cage. The kind, stand, and condition of wild host plants are recorded. The population is expressed in the number of leafhoppers per sample or per 100 square feet of weed-host area.

Beet leafhopper counts are made in sugar-beet fields with the square-foot sampler. The samples, which include more than one plant in unthinned fields but single plants in thinned fields, are taken at random along the beet rows. Generally, 100 samples are taken in each field - 25 samples in each quarter. The average population of leafhoppers is expressed in the number per sample or per beet plant.

Surveys are made in September to determine the magnitude of fall populations of the beet leafhopper in Russian-thistle areas and the extent and location of such thistle areas in southern Idaho and eastern Oregon. The transect method of recording plant cover is used to determine the acreage of Russian-thistle. Records are kept of miles traveled and the miles of Russian-thistle observed on each side of the road. The approximate number of square miles of Russian-thistle with each area is determined by means of the following formula:

$$\frac{\text{Transect miles of thistle}}{\text{Transect miles}} = \frac{x(\text{thistle area in square miles})}{\text{Total area in square miles}}$$

Quantitative samples with a 1/2-square-foot sampling fork 4/ is used in determining the population of leafhoppers. Ten fork samples are taken at each stopping point, the number of stops depending upon the area and condition of the Russian-thistle. At each stopping point, the Russian-thistle stand is determined by means of the pacing method. This consists of taking 250 double paces through the host-plant area. The number of living plants touched by the toe of the right foot in moving through an area is counted, and from this figure the percentage stand is calculated, e. g., if there were 125 living plants touched by the toe of the right foot in moving 250 double paces the stand is 50 percent. The condition and height of the thistle are recorded. From this information, the areas of Russian-thistle are computed and corrected to a 100-percent stand. By using the average density of leafhoppers

2/ Jones, E. W. 1937. Practical Field Methods of Sampling Soil for Wireworms. Jour. Agr'l Res., 54, (2), pp. 123-134. ill.

3/ Hills, O. A. 1933. A New Method for Collecting Samples of Insect Populations. Jour. Econ. Ent. 26: 906-910.

4/ Lawson, F. R., D. E. Fox, and W. C. Cook. 1941. Three New Devices for Measuring Insect Populations. Bur. of Ent. and Plant Quar. ET-183.

per unit-area and the acreage of thistle, the approximate number of leafhoppers can be determined. As an example, if Russian-thistle occupied an average of 54 percent of each acre examined and if the thistle plants were infested on an average by 57 beet leafhoppers per square foot of land surface occupied, on this basis there would be approximately 1,340,000 beet leafhoppers per acre. This survey gives the acreage of Russian-thistle and the size of the fall population of leafhoppers in the summer breeding areas. The principal breeding areas of the beet leafhopper in the western states have been located and delimited, and the surveys are confined to these areas.

Information obtained from these surveys, together with other pertinent factors, provides the basis for the issuance of statements on beet leafhopper conditions for southern Idaho to growers and other interested persons or agencies. (J. R. Douglass)

BEET LEAFHOPPER SURVEY USING A STANDARD SWEEP NET

While a sweep net is not considered as accurate as some other methods of survey for beet leafhopper, it is considered faster and it is believed its use will permit a practical estimate of leafhopper populations in a given area.

In using a sweep net, similar in form and size to a standard butterfly collecting net, three important factors must be considered: (1) weather, (2) condition of the host plant, and (3) type of host plant.

With respect to the weather, leafhoppers are not particularly active in temperatures below sixty degrees, lower temperatures forcing them close to the ground where they would be difficult to pick up with the net. Wind also will cause leafhoppers to remain well within the protection of the host plant. In either case it would be difficult to pick up a true representative population with a net and collecting should be avoided under such conditions.

With respect to the condition of the host, the latter may on occasion be quite dry in which case concentrations are forced onto the greener plants which should then be made the object of sweeping.

The manner of sweeping depends on the type of host plant involved. In the case of mature Russian-thistle and perennials, as normally encountered in the fall, survey is based on the number of hoppers recovered in a single sharp ninety degree sweep of the net. On the smaller winter annuals, three foot sweeps of the net made rapidly back and forth as close to the ground as possible, usually in multiples of ten, twenty-five or fifty sweeps, are followed. The number of leafhoppers thus recorded is based on the average number per sweep in relation to the number of sweeps made.

In general practice, survey is accomplished by sweeping at one-quarter to one-half mile stops throughout favorable-looking areas. Excepting where a single sweep is used on mature thistle and large perennials the usual practice is to take ten sweeps. However, if the population of leafhoppers is exceedingly low, as many as fifty sweeps may be used for each check. Where using ten sweeps, it is customary to make at least ten such unit checks at each location.

Generally speaking an average of five leafhoppers per ten sweeps is considered the minimum economic population meriting treatment. However, under certain conditions an average of two or three leafhoppers per ten sweeps over a large area can produce damaging numbers.

During the spring, survey is restricted to warm knolls having a southern exposure with sparse growth favorable to development of the spring generation. Sweeping in such areas in addition to determining the need for treatment is later made to check the time and extent of the spring flight back into the agricultural areas based on the number of female leafhoppers in such areas at the time of checking. Such survey is usually made by using the ten-sweep unit, sweeping as close to the ground as possible. (H. Green, California Dept. of Agri.).

POTATO PSYLLID

To determine the abundance of potato psyllid (Paratrioza cockerelli) populations, adult counts are made in approximately 10 potato fields per county, selected at random and examined at one-to-two-week intervals during the growth of the plants.

Potato psyllids are most numerous near the edges and progressively diminsh in numbers toward the center of the potato fields. Adult counts are made with a 15-inch insect net, of unbleached muslin. Starting at one edge of the field and working toward the center along the rows, fifty sweeps are taken at intervals of about one pace. The net is swept briskly across the tops of the plants, covering approximately two-thirds of the net opening with the tops of the plants. Sampling is continued toward the center of the field, in units of 50 sweeps, until 2 to 4 units of samples are obtained, depending on the size of the field. Counts are recorded in numbers of psyllids per 100 sweeps.

Although survey records are based on adult counts, egg and numph counts may be made, if desired, by taking 50-leaflet samples at the same location that the adult counts are made. One leaflet is taken from near the center of each of 50 plants. The leaflets are examined in the laboratory under a low magnification lens and the eggs and nymphs are recorded in numbers per 50 leaflets. (R. L. Wallis)

APHID POPULATIONS ON POTATOES IN THE NORTHEAST

Populations of aphids in northeastern Maine are determined at intervals on potatoes receiving no insecticidal treatment and on potatoes treated commercially for the control of insects. In this area the potato plants usually are infested by winged and wingless forms of four species of aphids (buckthorn, green peach, potato, and foxglove aphids). The wingless forms -- ordinarily by far the more numerous on the plants -- cause direct feeding damage to the potato plants and also serve as vectors for certain virus diseases of potato. The winged forms are often of more importance than the wingless forms in spreading the virus diseases within and between fields of potatoes, and they also colonize plants in widely separated parts of the field. One species of aphid may be of greater importance than another as a vector of certain of the virus diseases and, because of size differences, in causing direct feeding damage to the potato plants. Therefore, in all aphid population counts, a record form is used to show the number of each species found on each sample unit.

Number and location of sample units: Experience has shown that it is not practical to determine aphid populations in an entire potato field. Consequently, the sample units are limited to one square acre in each field of commercially-grown potatoes examined. One hundred sample plants are located mechanically at random over the acre by a screen-grid method.

Unit and sub-units of sample: 1/ Early in the season, when plants and aphid populations are small, the entire hill is examined. After the plants are about 8 inches high the examinations are confined to 3 leaves on each sample plant. The leaves are examined *in situ*, care being taken not to disturb the aphids. One leaf is located at random within each of the top, middle, and bottom thirds of the plant. Later, if larger numbers of aphids develop, only the terminal and the 2 basal (lateral) leaflets of each leaf in each of the 3 standard positions are examined. Typically, potato leaves have 7 leaflets -- a terminal and 3 pairs of laterals. If still later even larger numbers of aphids develop, the sub-units consist of only half the area of these 3 leaflets in similar positions. All the leaf area on one side of a midrib of a leaflet constitutes a half leaflet. Detailed studies have shown that this is a valid sampling procedure. These half-leaflets are chosen so that 50 percent of them are on one side of the leaflet midrib and the rest on the other. For any one sample plant, however, the same side of the midrib for all 9 of the half leaflets is used.

1/ Abstracted from pages 9-10 of Bul. 480, Maine Agr. Exp. Sta., Control of Aphids on Potatoes with DDT when Used with Fungicides, by W. A. Shands, G. W. Simpson, P. M. Lombard, R. M. Cobb and P. H. Lung.

Expressing aphid populations: Populations are stated in terms of the average number of aphids of each species per plant. Winged and wingless forms are recorded separately. Except when the entire hill is used as the unit of sample early in the season, the number of aphids determined as the average is the average of those found on 3 whole leaves per plant. When the sub-unit consists of leaflets 1, 4, and 7, the 3-whole-leaf basis is approximated by dividing the average (for the 1-4-7-leaflet basis) by 38.1 and multiplying by 100. This formula was derived from a study of aphid distribution on potato leaves. Likewise, the 3-whole-leaf basis is approximated for counts involving sub-units of one-half of leaflets 1, 4, and 7 by using 19.05 as the factor instead of 38.1.

Information from surveys following this procedure permits comparisons between aphid populations at different locations as well as between the populations of the four species of aphids involoved. Because of differences in growth habits of different potato varieties, population comparisons between varieties and between years may be of less value. When made at regular intervals throughout the season in the same locations the counts indicate locality differences in rates of population increase. Actual aphid populations per plant--when sub-units of sample are involved--can be approximated by multiplying the averages for the 3-whole-leaf basis by one-third of the average number of leaves per stalk and that by the average number of stalks per hill. (W. A. Shands and G. W. Simpson).

APHID POPULATIONS ON POTATOES IN THE NORTHWEST

Only the green peach aphid (Myzus persicae) occurs in sufficient numbers to cause direct feeding damage to potatoes in the intermountain area of the Northwest. The extent of overwintering is indicated by the number of eggs found per six inches of twig in 25-twig samples taken from each of four peach orchards in February. At this time the location of 100 eggs is marked on the trees and the start of hatching and 50 and 100 percent of hatch is determined by examining those eggs every two weeks.

The start of aphid flight in the spring, and the seasonal intensity of flight from May to October, is determined from twice-weekly examinations of four, or more, Moericke-type traps which are placed at ground level near potato fields. This trap consists of an aluminum stew pan 8 inches wide and 2 1/2 inches high. Chrome-yellow enamel paint is applied to the inside of the pan to within one inch of the top. A quart of water in each pan serves as a trapping medium. The aphids are removed for identification and counting by pouring the water through a fine-mesh wire screen funnel.

Starting when the potato plants are four inches high, and continuing at approximately 14-day intervals until the early crop is harvested or the late-crop plants are frosted, 50 compound leaves are picked at random one leaf per plant - from the base of the plant in four fields of approximately the same planting age. Three categories of aphid abundance are obtained from the trap or leaf-sample examinations.

Classification	Number of winged aphids per trap (3-4 day collection)	Number of wingless aphids per 50 compound leaves of potato
Light	0 - 10	0 - 50
Moderate	11 - 100	51 - 500
Heavy	101 - 1000 plus	501 - 2000 plus

(B. J. Landis, E. W. Davis and K. E. Gibson)

PEA APHID

Three methods are commonly used in measuring pea aphid (Macrosiphum pisi) populations, the choice of method depending upon the host plants and size of the aphid population.

Sweepnet counts: The sweep net is used in very low aphid populations, such as occur in alfalfa late in the summer, or in peas just after the spring movement from alfalfa. A standard 15-inch collecting net is used, and a brisk sweep of about 3/4 of a circle is taken. (Two sets of samples are taken in representative parts of each field.) In taking a series of sweeps, the operator moves forward one or two steps at each sweep, to encounter previously undisturbed foliage. A few exploratory sweeps are taken to determine the size of sample. In general, a sufficient number of sweeps should be taken to collect from 50 to 100 aphids, but in very low populations this may not be possible, and under these conditions a sample of 25 or 50 sweeps should be taken.

Board Counts: These are used in general survey work, on moderate to high populations of pea aphids. The board is a thin piece of board about 10 x 18 inches in size, containing an area 6 x 12 inches that is marked off into smaller squares. The board is held below and to one side of the tips of a row of pea plants, and the aphids on the plants dislodged by shaking the plants with the free hand. Only the aphids which fall inside the marked portion of the board are counted. In very high populations, the aphids are counted only on alternate squares, in checkerboard fashion. Ten randomly distributed board samples are taken from each field or station.

Tip Counts: This type of count is used in general survey work on moderate to high populations. The operator walks across the field holding an open paper sack in one hand and picking tips at random with the other hand. The tips are from 4 to 6 inches long, and are picked with a twisting motion of the hand so that the tip, when severed, is held over the open palm, to catch any aphids that may be dislodged. The tips are dropped into the paper bag, which is then closed and stapled, and taken to the laboratory for counting. At the laboratory the bags are placed in a large container and fumigated with a few cc. of methyl-iso-butyl ketone for about 10 minutes. This makes the aphids loosen their hold on the plants. The contents of the bags are then shaken over a 4-mesh screen so that the aphids drop through and the plants remain. Flat black or white boards may be used to catch the aphids for counting. As with the sweep net, the number of tips per sample is varied with the aphid population. Two 50-tip samples are needed for populations much lower than 1 aphid per tip, while two 5- or 10-tip samples is sufficient for aphid populations higher than 10 per tip. It is generally difficult to count more than 300 to 500 aphids per sample, and the number of tips per sample should be reduced in high populations to give about this total number of aphids.

Correlation of Methods: Because of the varying conditions under which the above methods are used ordinarily, a close correlation is not possible. However, in general on alfalfa a population of 1 aphid per tip is about equal to 30 aphids per sweep. On peas, a population of 1 aphid per tip is about equal to 3 to 4 aphids per board or per sweep. (W. C. Cook)

Populations of Potato-Infesting Aphids and of Aphid Eggs on Primary Hosts in Maine

Since 1942 a study of the populations of winged and wingless aphids and of aphid eggs on the more important primary hosts of three species of potato-infesting aphids in northeastern Maine has been in progress. The potato-infesting species included in the study have been the buckthorn aphid(Aphis nasturtii Kltb. (=abbreviata Patch)), the green peach aphid (Myzus persicae) and the potato aphid (Macrosiphum solanifolii). The more important primary hosts of these aphids, respectively, are alder-buckthorn (Rhamnus alnifolia) Canada plum (Prunus nigra) and wild roses (Rosa spp., chiefly swamp rose, R. palustris).

During the course of this study some methods have been devised and tested which appear to provide estimates of populations of the aphids and of aphid eggs on the more important primary hosts. Some of these methods appear to be suitable while others are not entirely satisfactory. All can doubtless be improved upon. An outstanding result of the study has been the realization that except in the instance of the buckthorn aphid, fall and spring surveys of aphid egg abundance are of much reduced value without a knowledge of the size and composition of the fall aphid populations on the primary hosts. A knowledge of population trends of the aphids on these hosts in spring is also of value in anticipating the probable time and size of the spring migrations since the operation of many factors may tend to change the outlook for size of the spring migration.

Populations of the Aphids

The potato aphid: One hundred randomly located units are examined in determining the size of potato aphid population at each observation station of wild roses. Depending upon time of year and stage of plant growth three units of sample are employed. Two of these are used in the spring and the other one in the fall. Both units in the spring are located on the terminals of limbs, branches, or stems of the plant. The early-season unit is all new growth on the terminal 6 inches at these places on the plants. This unit is used from the time the eggs begin to hatch until the young leaves begin to unfold. From then until the spring migration of the aphid is complete the unit is all new growth on enough buds at branch or stem terminals to make a total of 6 inches of new growth. Records for each unit include the number of buds examined having new growth, the number of buds infested by the potato aphid, and the total number of potato aphids found. These data are essential in comparing potato aphid population sizes at different places, and in determining population trends at any one place. Aphid populations are expressed as (1) the average numbers of winged and of wingless potato aphids per unit, per infested unit, per bud or new growth from single buds, and per infested bud; and (2) the percentage of infested units or buds.

The whole compound leaf is the unit of sample from the start of the fall migration until fall breeding is complete. Fall populations of the potato aphid are expressed as the average number of potato aphids per leaf and the percentage of leaves infested. After the leaves begin to fall an estimate is made of the percentage of leaves still attached.

The green peach aphid: Populations of the green peach aphid on Canada plum are determined (1) at the spring peak of abundance of aphid colonies, and (2) from the beginning time of the fall migration until all of the leaves have fallen. The determination in spring is made at the time when the spring migration of the green peach aphid is at the peak, usually about the middle of June. This determination is based upon (1) the number of aphid colonies observed by two workers concurrently searching, for the same unit of time (usually 10 minutes), in separate parts of the same plum thicket, and (2) collections of a representative number of the colonies found. The workers must know how to recognize at a glance the presence of an aphid colony, as well as the locations and types of growth most likely to be infested. Examination of the collected specimens is made with a binocular microscope to determine the number of colonies containing the green peach aphid only, and the number with species in addition to the green peach aphid. Abundance of the aphid is expressed as the average number of aphid colonies found per minute of observation, the percentage of colonies infested only by the green peach aphid, and the percentage of green peach aphid colonies also containing other species of aphids.

Fall populations of the aphid are determined by examining 100 randomly located leaves on plants of Canada plum in each thicket. Once the leaves begin to fall, an estimate is made of the percentage of leaves still attached to the plum trees. Fall populations of the aphid are expressed as the average numbers of winged and of wingless forms per leaf and per infested leaf.

The buckthorn aphid: Populations of the buckthorn aphid are determined on alder buckthorn from the beginning time of the fall migration until fall breeding is complete or until the apterous forms become so numerous that extensive movement of the aphid occurs over the plants. After the foliage begins to drop records are made to show the percentage of leaves still attached. At each location a count consists of examining 100 randomly-located, attached leaves. The population is expressed as the average numbers of winged and of wingless buckthorn aphids per leaf and the percentage of leaves infested.

Because of the small size and the breeding habits of this aphid, no satisfactory method has been devised to determine spring populations of the buckthorn aphid on its primary host. Some indication has been obtained at the spring peak of aphid abundance by examining for aphids all new growth of three or four terminal buds at the tips of branches or stems. Population size is expressed as average number of colonies per branch or stem terminal and the percentage of terminals infested.

Populations of Aphid Eggs

Populations of aphid eggs on the primary hosts are determined semi-annually, in the fall after egg deposition is complete and again in late spring just before hatching starts. These times usually are early in November and late in April.

Canada plum and alder-buckthorn: Nine bunches of 10 twigs each are randomly cut from branch or stem terminals in 9 separate sections of each thicket of Canada plum or patch of buckthorn. The terminal 9 buds on each twig are then examined in the laboratory with the aid of a binocular microscope to determine the number of aphid eggs by each bud. Records by bud position or number are made to show for each the number of fully distended and the number of shrivelled eggs found. An egg is considered as being shrivelled if it is not perfectly distended. Populations are expressed as the average number of each kind of eggs per 100 buds.

Wild roses: Examinations of wild roses for aphid eggs are made in the field with the aid of a reading glass and a hand lens. Two units of sample are employed in each rose patch, viz., the terminal 9 buds on each of 30 randomly located branch or stem terminals, and 270 individual crotches of branches and limbs. Records are made to show by bud position or crotch number the numbers of fully distended and shrivelled eggs. An egg is considered as being shrivelled if it is not perfectly distended. Populations are expressed as the numbers of fully distended and shrivelled eggs per 100 buds or crotches.

Location of Sample Units

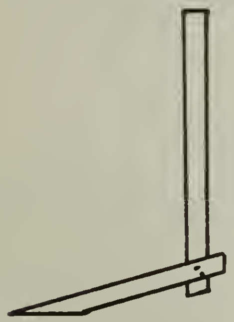
Random location of sample units in all of these procedures is essential, both vertically on the plants and to include all parts of the area covered by the host at each station. The results of some observations of the potato aphid on swamp rose illustrate the importance of random sampling in any effort to compare between locations, populations of the aphid or of aphid eggs. Equally important considerations are involved for other species of aphids on their primary hosts.

In the fall the potato aphid is more abundant on yellowing leaves than on green ones. Yellowing leaves are usually more abundant inside and near the base of the plants than at branch or stem terminals or outer parts of the plants. In the spring the aphids breed most commonly at the tip of new growth, irrespective of location on the plant. Frequently, the populations are larger than elsewhere on young rose shoots near the base of the plant and inside the rose patch. Populations of the eggs and of the aphids are larger, both in fall and in spring, on rose plants growing inside hedgerows or narrow bands of trees than on similar plants growing outside or in unprotected places. The composition of the aphid population and of the aphid eggs may vary tremendously on rose plants within a small patch that appears to be very uniform as to sameness of environmental conditions. (W. A. Shands and G. W. Simpson).

WESTERN BEAN CUTWORM

The examination of beanfields for western bean cutworm (Loxagrotis albicosta) should first be directed toward the detection of holes in the pods by the larvae and, second, if they are found, toward the cutworm itself. Since other insects eat similar holes in the pods, the larvae must be found for positive identification of its presence. If the beans have not been cut, an examination should be made of 100 feet of row located in the center of the field and 100 feet of row located near the approximate center of each quarter of the field, involving the examination of a total of 500 feet of row per field. To facilitate turning the vines and exposing the pods, a

vine lifter could be used to advantage. (see diagram). The handle is made from 1-5/8 x 3/4" lumber and is 39 inches long. The blade is made from 1-1/4 x 3/8" lumber and is 17 inches long. If holes are noted in the bean pods, the plants should be slapped so as to knock any larvae that may be on the plants into the middle of the row. The soil under the plants should also be examined for these larvae, since they often burrow into the soil around the plants. If the bean plants have been cut and windrowed or shocked, an examination should



be made of 20 feet of windrow in the center of the field and 20 feet located near the approximate center of each quarter of the field, involving the examination of 100 feet of row per field. In examining the vines, they should be raised, shaken, turned, and placed to one side. Larval pellets are dropped on the soil-surface, and when they are observed either under the plants or windrows, the larvae are generally readily found. For the distribution and description of the insect see the article by J. L. Hoerner, "The Cutworm Loxagrotis albicosta on Beans," Jour. Econ. Ent. 41(4): 631-635, 1948. (J. R. Douglass).

PEA WEEVIL

Since pea weevil (Bruchus pisorum) populations in infested pea fields are most often concentrated in a narrow zone around the edges, especially in larger fields, it is frequently unnecessary to apply control measures to the entire planting. Parts of the field that require dusting may be determined quickly and accurately by making adult counts through use of a 15-inch net. Sweepings are made soon after the first blossoms appear and before controls are applied. The inspector goes into the field in several places on each of the four sides or at intervals in an irregularly shaped field. Two or more 25-sweep collections are made at each selected location (beginning at edge of field or 100 feet inside the margin), with strokes across the upper parts of the vines spaced at one or two paces. As each collection is completed, weevils are counted and number and location recorded on a rough diagram of the field. Inspection progresses at 100-foot intervals toward the center of the planting until no weevils are found. In peas grown for seed, survey is made toward center of the field to the point where weevil number falls below the economic level.

Due to influences such as weather and time of season, it is impossible to accurately establish an expected infestation rating resulting from a given number of weevils, as determined by sweeping, in an average field of peas. Weather has an important effect on both yield and weevil activity. The same number of weevils produce a greater infestation in late varieties than in early varieties. A population of 5 weevils per 50 sweeps may cause infestation at the canning stage of 1 to 2 percent in early varieties, whereas the same population may cause infestation at the same stage of 10 to 25 percent in varieties blooming after June 15. An infestation of 1 weevil in 25 sweeps on the growing plants at time of blooming causes from 3 to 8 percent infestation in peas harvested for seed.

In making this survey particular attention is given to areas in the field most likely to be severely infested including borders adjacent to wooded or brushy areas, buildings, ravines, gullies or any area where the first peas blossomed. After the initial inspection, fields are rechecked 18 to 24 hours after dusting to determine the effectiveness of the control operation. (The Pea Weevil and Methods for Its Control, Farmers' Bul. No. 1971, U.S.D.A.)

COTTON INSECTS

The following suggested methods for making uniform cotton insect surveys were formulated at the Cotton Insect Research and Control Conference held in Memphis, Tennessee, December 7-9, 1952.* It was agreed at the conference that these methods are not final but would serve as a guide in the development of standardized survey procedures.

Boll Weevil

Survey records are made in a number of States to determine winter survival of the boll weevil. Counts are made in the fall soon after weevils have entered hibernation and again in the spring before they emerge from winter quarters. A standard sample is 2 square yards of surface woods trash taken from the edge of a field where cotton was grown during the season. At least five samples are taken from a location.

In the main boll weevil area, population counts are made on seedling cotton to determine the number of weevils entering cotton fields from hibernation quarters. The number per acre is figured by examining the seedling plants on 50 feet of row in each of five representative locations in the field. Additional counts are desirable in large fields.

Examinations for boll weevils are made weekly after the plants are squaring freely or have produced as many as three squares per plant. While walking diagonally across the field pick 100 squares. They should be one-third grown or larger, and an equal number should be picked from the top, middle, and lower branches of the plants. Squares from the ground or dried-up squares that are hanging on the plant should not be picked. The number of squares found to be punctured is the percentage of infestation.

An alternative method is to inspect about 25 squares in each of several locations distributed over the field. The number of sample counts will depend upon the size of the field and the surrounding environment. Accurate infestation records in large fields will require additional counts in different parts of the field. The percentage of infestation is determined by counting the punctured squares.

In both methods, all squares that have egg or feeding punctures should be counted as punctured squares.

Bollworm

Examinations for bollworm eggs on cotton should be started when most of the corn silks in the area begin to dry, or at the time bollworms usually appear. Examinations should be repeated every 5 days if possible thereafter until the crop has matured.

While walking diagonally across the field, examine 100 main-stem terminals (about 3 or 4 inches of the top of the plant) for eggs and worms. If eggs are found on the terminals and 4 or 5 small larvae in the small squares or on the tender top leaves, the infestation is sufficiently heavy to start treatment. Insecticides should be applied at 5-day intervals as long as necessary.

To determine injury, inspect 100 bolls and 100 squares while walking diagonally across the field and compute the percentage of injury for each. The boll-injury record is the most indicative of existing or occurring damage.

In an alternative method of estimating bollworm damage make observations while walking diagonally across a field. The degree of injury may be recorded as follows:

None, if no damage is observed.
Light, if only a few squares and bolls show injury.
Medium, if injured squares and bolls are readily noticeable over most of the field.
Heavy, if numerous injured squares and bolls are noticed over the field.

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* Rev. by Cott. Ins. Res. and Cont. Conf., December 14-15, 1953.

Cotton Aphid

To determine early -season aphid infestations, while walking diagonally across the field make observations or inspections of many plants. Degrees of infestation may be recorded as follows:

None, if none is observed.
Light, if only a few aphids are found on an occasional plant.
Medium, if aphids are present on numerous plants and some of the leaves show a tendency to curl along the edges.
Heavy, if aphids are numerous on most of the plants and if the leaves show considerable crinkling and curling.

To determine aphid infestations on fruiting cotton, begin at the margin of the field and, while walking diagonally across it, examine 100 leaves successively from near the bottom, the middle, and the top of the plants. The degree of infestation, according to the average number of aphids estimated per leaf, may be recorded as follows:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 or more

Cotton Fleahopper

Weekly inspections for the cotton fleahopper should begin as soon as the cotton is old enough to produce squares and be continued until the crop is set and begins to mature. About 3 or 4 inches of the top of the main-stem terminal of 100 cotton plants per field should be examined. Both adults and nymphs should be counted, the number per 100 terminals being recorded as the infestation for the field. The examinations should be made at several representative points diagonally across a field, 33 terminal buds being inspected approximately 50 feet from each of the 2 corners and 34 terminal buds at the center of the field.

Cotton Leafworm

The following levels of leafworm infestation, on the basis of ragging and the number of larvae per plant, are suggested for determining damage:

None, if no leafworms are observed.
Light, if 1 or only a few larvae are observed per field.
Medium, if 2 to 3 leaves are partially destroyed by ragging, with 2 to 5 larvae per plant.
Heavy, if ragging of leaves is extensive with 6 or more larvae per plant, or if defoliation is complete.

Pink Bollworm

Inspections to determine the degree of infestation in individual fields should be made as follows:

For infestation of blooms: Early in the season, make infestation counts when there is an average of at least one bloom for every four or five plants, but not more than one bloom for every two plants. Beginning at the margin, walk diagonally across the field and inspect several hundred blooms per field for those rosetted. The number of rosetted blooms should be recorded on a percentage basis.

For infestation of bolls: While walking diagonally across the field, collect at random 100 green bolls that are hard or firm when pressed. Examine each boll as follows: Remove the bracts and calyx by cutting off a thin slice of the base of the boll; cut each section of the boll midway between the sutures so that each lock can be removed intact; examine the inside of the carpel for the characteristic tunnels or mines made by the young larvae. The number of bolls found infested represents the percentage of infestation.

Other inspection techniques: There are other inspection methods besides those listed above that are most helpful in directing control activities against the pink bollworm. These make possible the detection of infestations in previously uninfested areas and the evaluation of increases or decreases in infestation as they occur in infested areas. They are also used to determine the population of larvae in hibernation and the survival or carryover of such larvae to infest the new cotton crop. These methods are as follows:

1. Inspection of gin trash: Procure freshly ginned "first cleaner" trash, which has not been passed through a fan, from as many gins as possible in the area to be surveyed. Maintain the identity of each sample of trash and examine it by separating mechanically all portions of the trash larger and all portions lighter in weight than the pink bollworm. A small residue is left which must be examined by hand. This method is extremely efficient for detecting the presence and abundance of the pink bollworm in any given area. However, it does not usually reveal the exact field or the percentage of field infestation.

2. Inspection of lint cleaner: This is another method for detecting the presence of the pink bollworm. The free larvae remaining in the lint during the ginning process are separated in the lint cleaners and a substantial number of them are thrown and stuck on the glass inspection plates of the cleaners. All larvae recovered from this method are dead. For constant examination at a single gin, wipe off the plates and examine after each bale is ginned. By doing this, the individual field that is infested may be determined. For general survey, make periodic examinations to detect the presence of the pink bollworm, in a general area.

3. Examination of debris: Between January and the time squares begin to form in the new crop, examine old bolls or parts of bolls from the soil surface in known infested fields to determine survival of hibernating larvae. Examine the equivalent of 100 bolls and count the living larvae. From these data the number of larvae remaining in hibernation at any given date may be determined. Such records when carried on from year to year provide comparative data which may be used in determining appropriate control measures.

4. Light traps: Especially designed traps using mercury vapor or black light fluorescent bulbs will attract pink bollworm moths. Such traps have been used to discover new infestations and their usefulness and value for survey work should be fully explored.

Spider Mites

In making inspections for spider mite infestation, begin at the margin of the field and while walking diagonally across it examine 100 leaves or more taken successively from near the bottom, the middle, and the top of the plants. The degree of infestation, according to the average number of adult females estimated per leaf, may be recorded as follows:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 or more

Thrips

To make inspections for thrips infestations, begin at the margin of the field and while walking diagonally across it observe or inspect numerous plants. The degree of damage may be recorded as follows:

None, if no thrips or damage is found.
Light, if newest unfolding leaves show only a slight brownish tinge along the edges with no silvering of the underside of these or older leaves and only an occasional thrips is seen.
Medium, if newest leaves show considerable browning along the edges and some silvering is evident on the underside of most leaves and thrips are found readily.
Heavy, if silvering of leaves is readily noticeable, terminal buds show injury, general appearance of plant is ragged and deformed, and thrips are numerous.

* * *

Not included in the conference report are several cotton insect survey methods which have been developed. Two of these methods follow:

Ground Trash Examinations for Boll Weevil
(as conducted at Tallulah, Louisiana)

Since 1936 trash examinations have been made in the Tallulah, Louisiana area in both fall and spring -- during the fall to determine the number of boll weevils entering hibernation; and during spring, the number which have survived. The so-called fall examination is usually made during the latter part of November and early December, or after temperatures which have forced weevils into hibernation. The spring examination is usually made during the latter part of February and early March. In making the examinations, ten 3 x 6 foot samples of surface trash, including about an inch of the topsoil, is carefully scraped up and placed in a bag from each location. The locations are selected near the edges (within 50 feet) of fields planted to cotton during the previous season. Approximately 20 locations, or fields, are sampled during both the fall and spring examinations. The samples are brought to the laboratory where they are run through a machine which is a modification of a soil sifter. This device divides the trash samples into three fractions: (1) very coarse material, consisting of leaves, twigs, etc.; (2) intermediate-sized particles of trash; (3) very fine material. The weevils are found in the intermediate sample. (Cotton Ins. Sec.).

Methods of Surveying for Pink Bollworm
(as used by Pink Bollworm Control Project, PPCB)

The inspection of cotton for pink bollworm falls under four types or methods: the inspection of Blooms, Bolls, Debris, and Gin Trash. Each method yields information of a definite nature on the spread and intensity or build-up of the infestation at a certain point or period in the season, such information being the basis for quarantine and control measures.

Bloom Inspection: The method employed with this type of inspection is to make counts of the noninfested blooms and the infested blooms in a given field or part of a field, thus enabling the working out of the percent of infestation. With some experience, the inspector is readily able to detect the infested blooms by their rosetted appearance. Under usual conditions the rosetted, or infested, bloom remains closed, with the outer edges of the petal flared, after the noninfested bloom is open. By knowing the percent of the blooms infested, information is gained which indicates the previous winter's survival and the probable severity of the infestation for the growing season ahead, thus, forecasting the need for control measures. A 5% infestation in the early blooms is considered as forecasting economic damage.

Boll Inspection: The inspection of green cotton bolls for pink bollworm is performed for several specific purposes, such as, to keep abreast with the increase or decrease in infestation, to obtain information as to the effectiveness of control measures, and to locate spread to new areas where the inspection of gin trash is not practical; also, boll inspection is used to determine late season build-up or spread after harvest of the crop has been completed.

The usual method employed in the inspection of bolls is to examine twenty bolls from five representative points in the field, usually near each corner and the center. The percent is found on the 100 bolls examined. Ten percent to 12 percent infestation early in the season will probably cause economic damage. To detect the early stage of the larva in the boll, the boll is carefully cut and examined, first by removing the bracts by cutting off a small layer from the base of the boll, then cutting lengthwise of the boll midway between the sutures in such manner that when the boll is opened the lock will be whole and unbroken and the partitions or carpel walls between the locks will be undamaged by the cutting operation. Examine the inter-carpel lining for the characteristic tunnels or mines made by the small worm. The number of bolls found infested represents the percentage of infestation. The newly hatched larva is very difficult to see, but the damage caused is more noticeable. It enters the green boll immediately after hatching and moves toward the locks and seed, leaving a small thread-like brown "railroad", or tunnel, as it moves or burrows its way along the inside of the carpel. These railroads are characteristic work of the pink bollworm and are readily detected by the experienced inspector. In the later stage the larva is usually easily detected not only by the damage caused, but the larva itself is normally readily found when the boll is opened. When opening the boll the later stages of damage are detected by noting the small round between the partition walls of the boll and the workings between the seed. If no damage is seen by this time the inspector does not generally cut the seed, but if damage is found, it may be necessary to cut the seed before actually locating the larva. A small round clean-cut hole is made in the outer wall of the boll only after the larva is mature and is preparing to leave the boll, or is preparing for moth emergence, where pupation takes place inside the boll which occasionally happens under certain climatic conditions. In late season the larva habitually seals itself inside a single seed or it pulls two seeds together to form "double seed." In the inspection of dry bolls or bollies, the method is much the same as the inspection of green bolls; however, this is late season inspection and the larva is expected to be mature, which makes necessary that more seed be cut in order to locate the larva sealed inside seed for weather protection during the overwintering stage. This type of inspection is done for the purpose of determining winter survival or mortality.

Debris Inspection: For inspection purposes debris is considered to be dry bolls, or parts thereof, consisting of pieces or parts of locks or seed cotton either on the soil surface or partly covered- this method also necessitates cutting considerable seed, and is conducted for the purpose of determining the effectiveness of stalk destruction and the effectiveness of different types of stalk cutters or shredders by determining the pink bollworm mortality. This method or type of inspection is also done for the purpose of determining winter carry-over in debris as compared to carry-over in bolls on the stalks or off the soil surface.

Gin Trash Inspection: A machine has been developed by the Pink Bollworm Project which aids in the inspection of gin trash. This machine employs screens and air cleaners to reduce the trash samples to a residue containing pink bollworm, if any, all insects contained in the cotton trash which are of comparable size and weight of the pink bollworm, plus a small amount of leaf stems, grass seed and small clods of dirt. This means that it is possible for the inspector to inspect trash representing cotton from a large number of bales and many different fields in the period of a day. The greatest value developed from this method is the quicker detection, at a lower cost, of an initial infestation of pink bollworm in an area not previously known to be infested. A secondary value of this method is to trace light infestations to individual fields. The inspection of gin trash is also a quick and economically sound means of obtaining comparative data from year to year showing the increase or decrease of infestations. Due to varying factors in the cotton cleaning machinery at the gins this method does not yield results which can be translated as percent damage in the field. (Welker and West).

A METHOD OF INSECT DAMAGE DETERMINATION ON SHADE-GROWN TOBACCO

During the year 1937 a field method of determining insect damage was developed for shade-grown, cigar-wrapper tobacco at Quincy, Florida. Its application apparently gave a fairly reliable index of the damage caused by hornworms, budworms, and flea beetles. The method was based upon the local tobacco packing house breakage grade system. The sales value of cigar-wrapper tobacco has advanced greatly, and the breakage grade system has undergone some changes since 1937, but the same principles of damage determination should be applicable today.

The breakage grade system assumes that four cigar wrapper cuts will be taken from each uninjured leaf. Very small holes close to the margin or midrib do not prevent the leaf from being classified in the first or "uninjured" grade. Leaves having about 25 and 50 percent of their area injured are placed in the second and third grades, respectively. All injury below the third grade places the leaves in the fourth or "brokes" grade. The average percent reduction in value in the three grades is shown in the table below.

Average Percent Reduction in the Value of Wrapper Tobacco in Breakage Grades 2, 3, and 4

Holes and Breakage	Grade	Av. selling price Length in inches					Average percent reduction in value
		12	13	14	15-20	Av.	
Leaves av. 95-100% uninjured	1st	.50	.75	1.25	1.75	1.06	0
About 25% of leaf-surface damaged	2d	.40	.55	.75	1.00	.68	36
About 50% of leaf-surface damaged	3d	.25	.40	.60	.85	.52	51
All below 3d grade "brokes"	4th	.08	.08	.08	.08	.08	92

Cured and sweated wrapper tobacco is graded for insect damage and other breakage in the packing houses by ordinary labor. The same grading can be performed in the field for purposes of damage estimation. In the latter case the inspector must be able to differentiate between injuries caused by the feeding of hornworms, budworms, and flea beetles, and the injuries produced by other causes. Discrimination between these different types of injury is performed most easily in the field.

In practice the scoring of insect injuries was performed in each field on five lots of ten plants each. Four of these lots were located 25-30 feet from each of the four respective corners of the field. The fifth lot was chosen near the center of the field. The leaves on the fifty plants were first counted and then scored separately for observable injuries produced by hornworms, budworms, and flea beetles. The average reduction in value caused by the respective insects was easily computed.

The accuracy of the described method could doubtless be improved by sampling and statistical procedures. (F.S. Chamberlin).

UNIFORM SURVEY PROCEDURE FOR DETERMINING SAMPLE SIZE
THE LAKE STATES FOREST INSECT SURVEY COMMITTEE - 1956

INTENSITY OF SAMPLING

PURPOSE:

The purpose of this brief section is to illustrate the evaluation of sample size. This problem confronts every investigator who plans to employ sampling for his enumeration job. The discussion considers chiefly simple random sampling, stressing the importance of proper evaluation of such items as the degree of expected variability in the statistic involved and the sampling accuracy desired.

DETERMINING THE NUMBER OF SAMPLE PLOTS:

The following formula should be used in determining the number of random sample plots required in estimating timber to the accuracy determined: The formula is based on original work by S. R. Gevoriantz and W. A. Duerr of the Lake States Forest Experiment Station. 1/

Formula: $$N = \frac{A(C)^2}{A(E)^2 + a(C)^2}$$

E = percent of accuracy expressed as decimal
A = total area to be sampled in acres
N = number of sample plots
a = area of the sample plot in acres
C^2 = coefficient of variation squared

Example: Given
A = 1,000 acres
E = .10 (10 percent)
C^2 = 1.0
a = .2 acres

Then: $$N \quad \frac{1,000 \times 1.0}{1,000 \times .10^2 + .2 \times 1.0} = 98 \text{ plots}$$

In setting up a sampling scheme, one frequently needs an a priori knowledge of the variability involved. One good measure of variability is the coefficient of variation. It can be estimated by knowing certain characteristics of the expected scatter of the individual samples. From previous experience it is possible, for example, to anticipate the range (R) of the total variability, or the difference between the maximum and the minimum values, their expected average, or the mean (M), and the percent of values (P) that would fall in the middle third of this range.

The approximate value of the coefficient of variation (C) can then be calculated from the expression worked out by S. R. Gevorkiantz which relates all three factors regardless of the type of distribution involved.

1/ Forest Survey Section, Timber Management Handbook R-9, Forest Service 65-Appendix, Amended March, 1953. Examples on pages 676, 677, 678 are from this Section.

$$C = \frac{R}{(1 + \frac{P}{14})\,M}$$

Example 1:

M = 8 cords per acre

R = 16 cords per acre

P = 56 percent

$$C = \frac{16}{(1 + 4)\ 8} = \frac{16}{40} = .40$$

Example 2:

M = 7 cords per acre

R = 16 cords per acre

P = 28 percent

$$C = \frac{16}{(1 + 2)\ 7} = \frac{16}{21} = .76$$

For a more accurate evaluation of C, a reconnaissance survey is required. In this reconnaisance, a few plots, well scattered over the area, can be taken as a sample to indicate the total variability involved. Later on, more plots can be obtained to complete the survey.

The coefficient of variation is the standard deviation expressed as a percent of the mean. Information on computation of the standard deviation and coefficient of variation can be found in more recent mensuration texts. Bruce and Schumacher "Forest Mensuration" and Girard and Gevorkiantz "Timber Cruising" have good descriptions of the procedure.

Example of computation of standard deviation and coefficient of variation for a small number of plots:

Plot #	Vol/A	Deviation (d) (Plot vol. - M)	Deviation squared (d^2)
1	4	-2.9	8.41
2	6	- .9	.81
3	8	+1.1	1.21
4	5	-1.9	3.61
5	6	- .9	.81
6	12	+5.1	26.01
7	3	-3.9	15.21
8	0	-6.9	47.61
9	8	+1.1	1.21
10	7	+ .1	.01
11	4	-2.9	8.41
12	11	+4.1	16.81
13	8	+1.1	1.21
14	14	+7.1	50.41
15	6	- .9	.81
16	10	+3.1	9.61
17	8	+1.1	1.21
18	4	-2.9	8.41
19	6	- .9	.81
20	8	+1.1	1.21
	138	-25.0	203.80
		+25.0	
Total disregarding sign		50.0	

Average or Mean (M) = $\frac{138}{20}$ = 6.9

Std. Deviation (S) $= \sqrt{\frac{\Sigma d^2}{n-1}} = \sqrt{\frac{203.80}{19}} = \sqrt{10.72} = 3.27$

Σ = Total or Sum of

n = Number of plots

Coefficient of Variation (C) = $\frac{S}{M}$ =

$\frac{3.27}{6.9}$ = .47 (expressed as a decimal)

For a large number of plots the computations by this method are laborious and can be shortened by setting up a frequency table. This method is particularly convenient for calculating the coefficient of variation after all data are collected. An example of this procedure, based on an assumed cruise in a pulpwood stand where 213 plots were taken, is given below:

Class limits	Midpoint class	No. of plots	Deviation from Assumed Mean (A)	d^2	nd	nd^2
	x	n	d			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0- .99	.5	1	-8	64	- 8	64
1.0- 1.99	1.5	4	-7	49	- 28	196
2.0- 2.99	2.5	7	-6	36	- 42	252
3.0- 3.99	3.5	13	-5	25	- 65	325
4.0- 4.99	4.5	12	-4	16	- 48	192
5.0- 5.99	5.5	17	-3	9	- 51	153
6.0- 6.99	6.5	24	-2	4	- 48	96
7.0- 7.99	7.5	29	-1	1	- 29	29
8.0- 8.99	8.5	28	0	0	0	0
9.0- 9.99	9.5	21	+1	1	+ 21	21
10.0-10.99	10.5	18	+2	4	+ 36	72
11.0-11.99	11.5	15	+3	9	+ 45	135
12.0-12.99	12.5	12	+4	16	+ 48	192
13.0-13.99	13.5	6	+5	25	+ 30	150
14.0-14.99	14.5	4	+6	36	+ 24	144
15.0-15.99	15.5	2	+7	49	+ 14	98
Total		213			-319 +218 -101	2,119

$$x = \frac{\Sigma (nd)}{\Sigma n} = \frac{-101}{213} = -.474$$

$$M = A + x$$

$$M = 8.5 + \frac{(-101)}{213} =$$

8.5 - .47 = 8.03 cords
Average volume per A.

$$C = \frac{S}{M} = \frac{3.13}{8.03} = .39$$

$$C^2 = (.39)^2 = .1521$$

$$S = \sqrt{\frac{\Sigma (nd^2)}{\Sigma n-1} - x^2}$$

$$S = \sqrt{\frac{2119}{212} - (-.474)^2}$$

$$S = \sqrt{9.995 - (.225)} = \sqrt{9.77}$$

$$S = 3.13 \text{ cords}$$

M = Mean or Average
A = Assumed Average
x = Correction to Assumed Average
n = Number of Plots
d = Deviation from Assumed Average
S = Std. Deviation
C = Coefficient of Variation

The procedure used is as follows:

1. When individual plot data have been collected, set data up in a frequency distribution table in columns 1, 2, and 3. That is, combine data into classes showing class limits in column 1, midpoint of class in column 2, and number of plots (n) in that class in column 3. Tabulate classes in order of size.

   There is no definite rule as to the number of classes to use, but it should be between 5 and 30. As a guide, use 6 - 10 classes for less than 100 plots, 10 - 15 for 100 to 1,000 plots, and 15 - 25 for over 1,000 plots.

2. Assume an average or mean (A) - which should be near the center of the frequency distribution. In a normal distribution the class having the highest number of plots will be near the average.

3. Subtract the midpoint of each class from the assumed mean and enter in column 4. This is the deviation (d) from the assumed mean (A).

4. Square this deviation (d) and enter in column 5.

5. Multiply the number of plots (n) in each class from column 3 by the deviation (d) from column 4 and enter in column 6.

6. Multiply the deviation squared (d^2) from column 5 by the number of plots in each class (n) from column 3 and enter in column 7.

7. Total columns 3, 6, and 7.

8. Then the correction (x) for the assumed mean equals the total of column 6 divided by the total of column 3 or $\frac{\Sigma nd}{\Sigma n}$ where the symbol Σ means "total."

9. The Mean (M) or average equals the assumed Mean (A) plus the correction (x) from step 8. M = A + x.

10. The standard deviation (S) equals:

$$S = \sqrt{\frac{\Sigma \quad nd^2}{\Sigma \quad n-1} \qquad -x^2}$$

In estimating the intensity of sampling needed, special attention should also be given to the degree of accuracy (E) assumed for the job. Although it is well recognized that E should vary with the importance of the statistic involved, many mistakes are made in overlooking the fact that E should vary with the area covered by sampling. It is improper, for example, to assign the accuracy of 10 percent (E = .10) for the survey involving 40 acres as well as for the one involving 40,000 acres, unless an effort is made to expand the value of the coefficient of variation (C) to allow for the natural increase in variability as the area gets larger. Although there is no special rule which would set the value of E for all jobs, it is believed that the minimum number of plots should be in the neighborhood of

$$N = 20\sqrt{A_0 C}$$

based on the assumption that percent sample (p) should be smaller than

$$p = \frac{20 \ a\sqrt{C}}{A_0}$$

where A_0 = area of the tract in units of 100 acres

C = coefficient of variation (decimals)

a = area of sample plot in acres

Thus, with C = 1.0, one would need on the area comprising 400 acres about

$$N = 20\sqrt{4x1} = 40 \text{ plots.}$$

If it is anticipated that separate statistics will be needed by different subdivisions of the total area, the required number of plots should be computed for each subdivision under consideration. Simple random sampling has been assumed throughout. More efficiency can be attained by stratification of the area. Any stratification will reduce the error of sampling even with a considerably smaller total number of plots. Instead of taking random samples over the entire area, the area can be separated first into units or condition classes which differ widely from each other but are essentially uniform within. The next step then would be to take plots from each unit or stratum. Let us assume that in the example above the area was divided into three homogeneous parts, each having more or less uniform conditions, and only one-half as many plots were employed. If the stratification is really good, it means that the coefficient of variation within each stratum should be considerably below 1.0 which is the relative variability of all observed values from the grand average comprising widely different conditions.

Assuming the within variation to range only from 0.2 to 0.4 we get:

Subdivision	Proportion of area (p)	Coefficient of variation (c)	Number of plots (n)	Error of variance c^2/n	Product c^2p^2/n
1	.4	.4	10	.016	.00256
2	.2	.3	5	.018	.00072
3	.4	.2	5	.008	.00128
	1.0		20		.00456

Here the sampling error is:

$$\sqrt{.00456} = .0675 \text{ or } 6.75 \text{ percent}$$

as compared to

$$\frac{1.0}{\sqrt{40}} = .158 \text{ or } 15.8 \text{ percent obtained by simple random}$$

sampling employing twice as many plots. The example above, of course, assumes very sharp stratification characterized by very uniform conditions within each stratum. This would be difficult to obtain in actual practice. The main principle of the reduction of error, however, will hold in all cases employing proper stratification. Whenever possibilities for real stratification exist, they should be considered in every sampling plan.

Uniform Survey Procedure Approved by
The Lake States Forest Insect Survey Committee - 1956

SARATOGA SPITTLEBUG NYMPHAL APPRAISAL SURVEY

PURPOSE:

These surveys are conducted to obtain data on nymphal populations of the Saratoga spittlebug so the needs for insecticidal control measures can be determined. They will ordinarily begin about June 15, in northern Wisconsin and Michigan, although weather conditions may necessitate setting the date as much as a week earlier or later. In any case the beginning date will be when most of the nymphs are in the later instars, and the survey should be completed before transformation to the adult stage begins.

INSTRUCTIONS:

Sample Size

Twenty sample plots shall be established per 100 acres of plantation. The individual plot encompasses an area of 1/10 milacre delimited by a portable square wooden frame (25 inches on a side, inside dimension). All plantations less than 50 acres will have 10 plots.

Plot Location

The plots must be evenly distributed according to lines predetermined on a plantation map. No plot should fall less than 2 chains from the edge of a plantation or a transecting road. The examiner will pace off the required distances and drop the plot frame immediately in front of him in an unbiased manner. The frame must not be moved from this point unless one or more of the following conditions are encountered:

1. No trees within 3 feet of the plot.--Always locate the plot frame so that it lies within 3 feet of the crown of a tree.

2. No ground cover.--If the trees have shaded-out the low-growing plants, move the frame to a more open area. If no suitable spot can be found within 1 chain of the predetermined sample station, note this fact on the field form and move on to the next station.

3. Trees over 15 feet or less than 2 feet in height.--If either of these conditions prevails, record the fact and move to the next station.

Alternate Host and Nymphal Count

At each sample station, each individual host plant and each nymph within the confines of the frame is recorded. To detect nymphs, carefully press away the ground litter from the root-collar of the plant and look for the characteristic spittle mass. If a mass is observed, pull it apart and count the nymphs. If as many as 10 nymphs are found in any one plot, it is not necessary to go on counting, simply note this fact and move on. Any additional alternate host conditions perceived by the examiner will be helpful in interpreting the data. For instance, if the "Others" column on the field form represents mainly hawkweed, or bracken fern, etc., a note should be made concerning its abundance.

Tree Size and Density

The average height of the trees, estimated to the nearest foot, and the average number of trees per acre must be recorded. The number of branch whorls on a representative (average sized) tree and any abnormal appearance of the trees such as deformation, flagging, etc., should be recorded.

The following points detail the use of the damage prediction table:

1. From the nymphal survey field form, the average number of tree units in the plantation is determined by obtaining the product of the average tree height (in feet), the average number of living branch whorls, and the average number of stems per acre. These three factors are determined by the observer in the field.

2. On the damage prediction table, the number of tree units is located in the column on the left and a straightedge placed across the table at this level.

3. From the nymphal survey field form, the total number of nymphs present in the first 1/10-milacre plot is determined.

4. This number is located in the top row of the damage prediction table and read downward to the point of intersection with the straightedge The infestation level on the 1/10-milacre plot is then designated (heavy, medium, or light) according to the infestation zone indicated by the table.

5. The infestation levels of all the rest of the plots are determined by examining the field forms and going through the steps described above.

6. If 30 percent or more of the plots fall in the heavy infestation zone, the plantation is slated for immediate control.

The infestation level in a particular plantation may not be high enough to warrant immediate control, but it may be high enough to anticipate the need for control the following year. For instance, if 20 percent of the sample plots were found to be heavily infested and an additional 10 percent moderately infested, it is only logical to assume that after the insect has gone through the propagative stage, the population will have increased enough to constitute a heavy infestation. Therefore, a plantation may be designated as requiring a nymphal survey and possible control <u>the following year</u> if 30 percent or more of the sample plots are moderately infested. In this manner both the operational and appraisal aspects of spittlebug surveys may be logically and effectively combined in a single spring nymphal survey.

Infestation Classification

The following empirical classification of tree damage on the basis of the feeding scar density on the xylem of the 2-year-old internodes has been established:

Feeding scars per 10 cm.	Tree damage level
0 to 10	Light
10 to 30	Medium
30+	Heavy

In order to classify an infestation on the basis of the spring nymphal population, the damage potential can be predicted according to the following relationship:

$$X = K\frac{A}{B}$$

X = number of feeding scars per 10 cm. of twig to be expected from the resulting adult population.

A = number of nymphs per 1/10 milacre.

B = number of tree units per acre = (number of trees per acre) x (average height of trees in feet) x (average number of living branch whorls per tree).

K = 17 (dimensionless constant).

A table showing the relationship between the three pertinent factors has been developed to simplify the classification of a particular nymphal population.

H. G. Ewan, Forest Service, U. S. D. A.

ALTERNATE HOST AND NYMPHAL SURVEY FOR SARATOGA SPITTLEBUG

FIELD FORM*

National Forest ______________ Ranger District ______________ Plantation Code No. ____________

Location: T. ____________ R. ____________ Sec. ____________ Acreage ______________

Date ______________________ Observer ______________________

Sample number	Number nymphs per stem	Number Alternate Host Stems			Sample number	Number nymphs per stem	Number Alternate Host Stems		
		Sweet-fern	Rubus spp.	Others			Sweet-fern	Rubus spp.	Others
1	0				6	0			
	1					1			
	2					2			
	3					3			
	4					4			
2	0				7	0			
	1					1			
	2					2			
	3					3			
	4					4			
3	0				8	0			
	1					1			
	2					2			
	3					3			
	4					4			
4	0				9	0			
	1					1			
	2					2			
	3					3			
	4					4			
5	0				10	0			
	1					1			
	2					2			
	3					3			
	4					4			

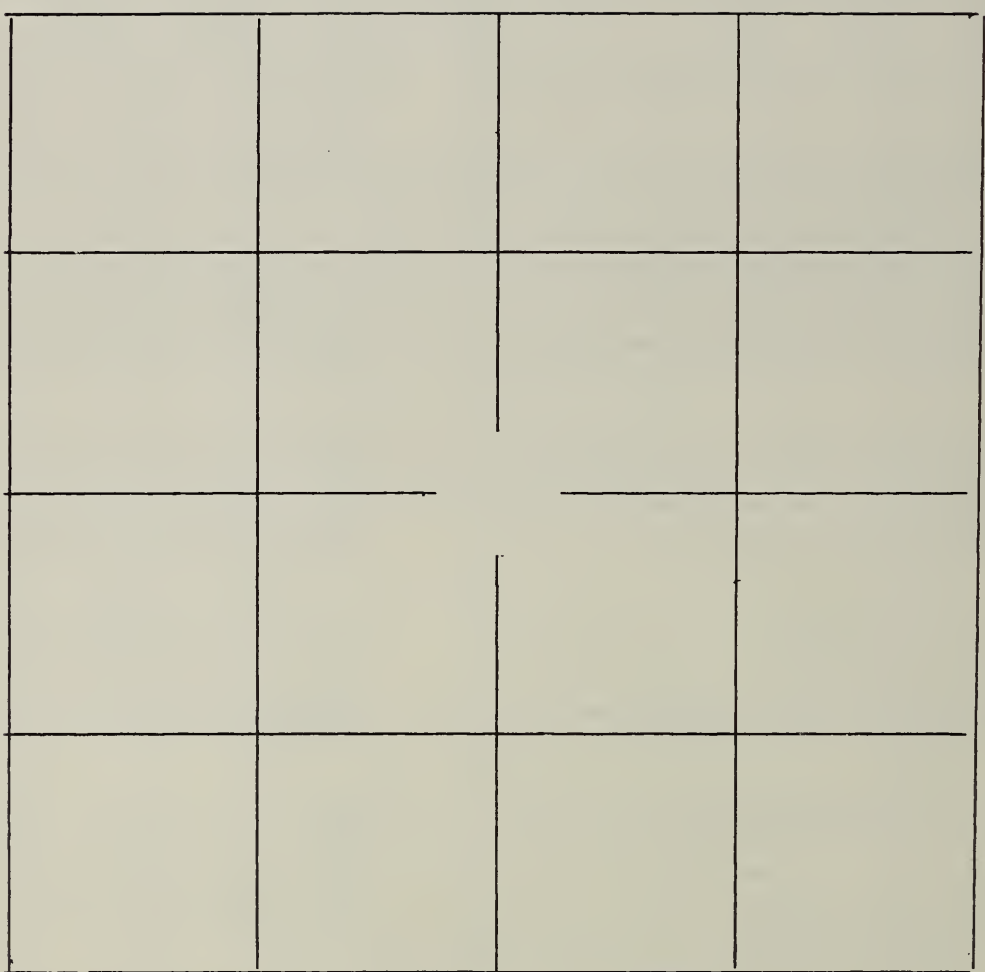
Average number trees per acre: ____________ Average number of branch whorls __________

Average height of trees (to nearest foot): ____________

Remarks:

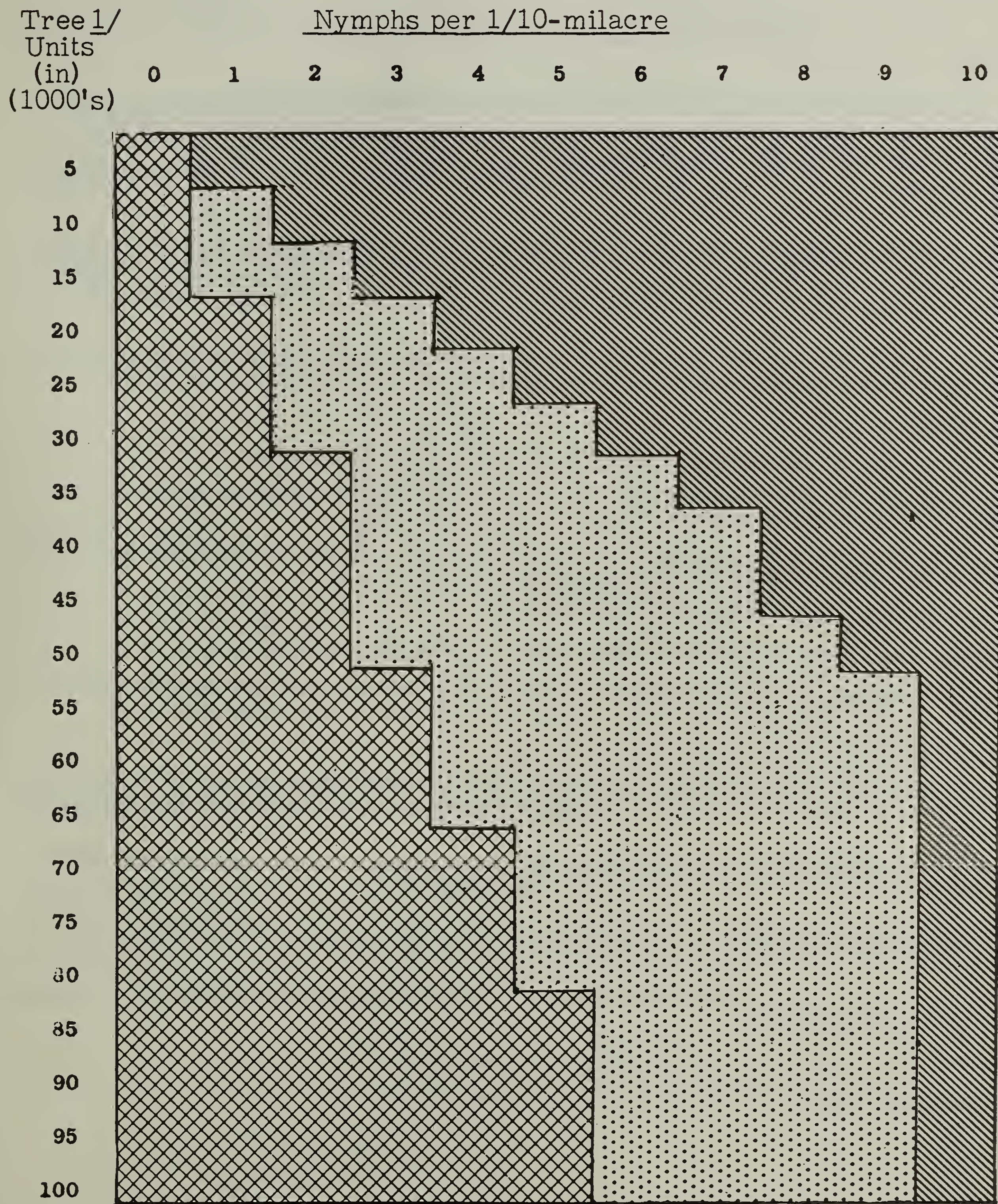
*A continuation sheet is used when there are 20 sample plots.

(Over)

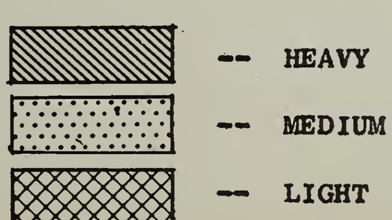


T. R. Sec.

Saratoga Spittlebug Damage Prediction Table



1/ A product of the average tree height (in feet), the average number of living branch whorls, and the average number of stems per acre.



UNIFORM SURVEY PROCEDURE APPROVED BY
THE LAKE STATES FOREST INSECT SURVEY COMMITTEE - 1956

PINE TORTOISE SCALE - APPRAISAL SURVEY

PURPOSE:

The purpose of this survey is to appraise the extent of infestation by the pine tortoise scale and to determine whether direct control measures are necessary. This insect is not conspicuous and, unless a methodical search is made, the scales may be missed. For example, in a 6 x 6 planting of jack pine trees, when collections are made at every thirteenth tree in rows which are 10 chains apart, and when the trees are approximately 20 feet high, only about 20 twigs out of roughly 1, 716, 000 are examined for scale, which obviously is a very low percentage.

Estimates of actual numbers of scales present are required so that comparisons can be made from year to year. If surveys are carried out fron one year to another, sufficient numerical data may be accumulated so as to be able to predict a point in a population rise where control tactics may be necessary. Information which will be of value for plotting tree survival, damage, or mortality, is also easily obtained at the same time.

The specific form is included which is to be filled out so that no information will be inadvertently omitted. With some preliminary instruction and supervision, untrained personnel can carry out the survey.

INSTRUCTIONS:

Instructions for Carrying Out Pine Tortoise Scale Survey

1. Use pole pruners which will reach to upper third of trees. Use standard length for any one plantation; usually two sections of pole will be sufficient.

2. Cut one branch from upper crown and, before recording information, take another branch from middle of the crown. This will save time in handling pruners.

3. Use pole pruners to estimate height of tree and record.

4. Take new growth of the cut branch and record number of immature scales per inch.

   If scales are present arounf entire branch, use figures for number of scales per inch from column two of chart. If scales are present on one side of twig only, use figures from column one.

5. Record number of predators present per inch of twig.

6. Measure length of new growth with ruler drawn on chart and record. Jack pine has one or more whorls of branchlets on new growth each year. To establish where new growth begins look for change of color in bark.

7. Estimate damage on sample tree and record in appropriate columns. If tree apparently will survive the attack, mark with check; if tree will not survive, mark with 0.

8. When recording tree mortality, make actual count of 100 trees. This can be done by counting 100 trees as seen from collecting point, i. e., count ten trees in five rows on each side of collecting point. Record in column as percentage of dead trees.

9. Work along row, even if direction of row changes. Take every thirteenth tree for sampling (when trees are spaced every 5 1/2 feet.).

10. Use only one row for counting trees between collecting points.

11. Sample may be taken from either side of row at thirteenth tree.

12. If thirteenth tree is dead, keep sampling space the same for taking next sample, but take sample from nearest living tree.

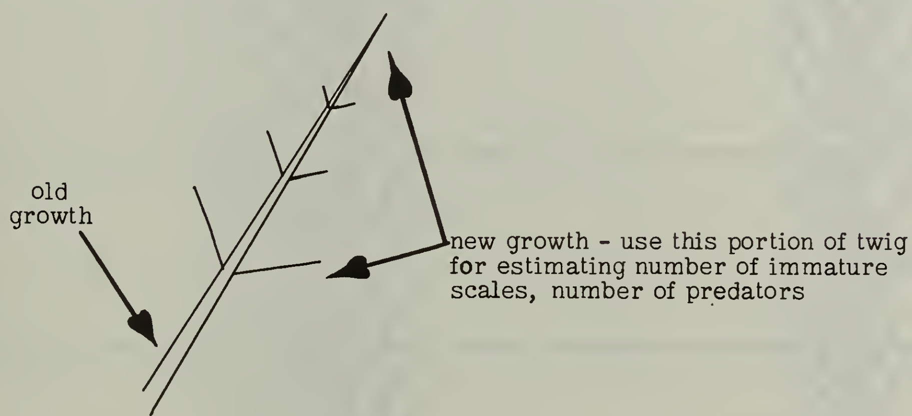
13. Record direction traveled in strip, direction plantation worked from, township, range, section and 40.

14. To take first sample, go along plantation 5 chains before starting first strip, then after first strip completed, take strips every 10 chains.

15. Attach to each sheet a mimeographed map of plantation being worked. On this map mark location, number and direction traveled for each sample strip.

16. Use separate sheet for recording information from each sample strip.

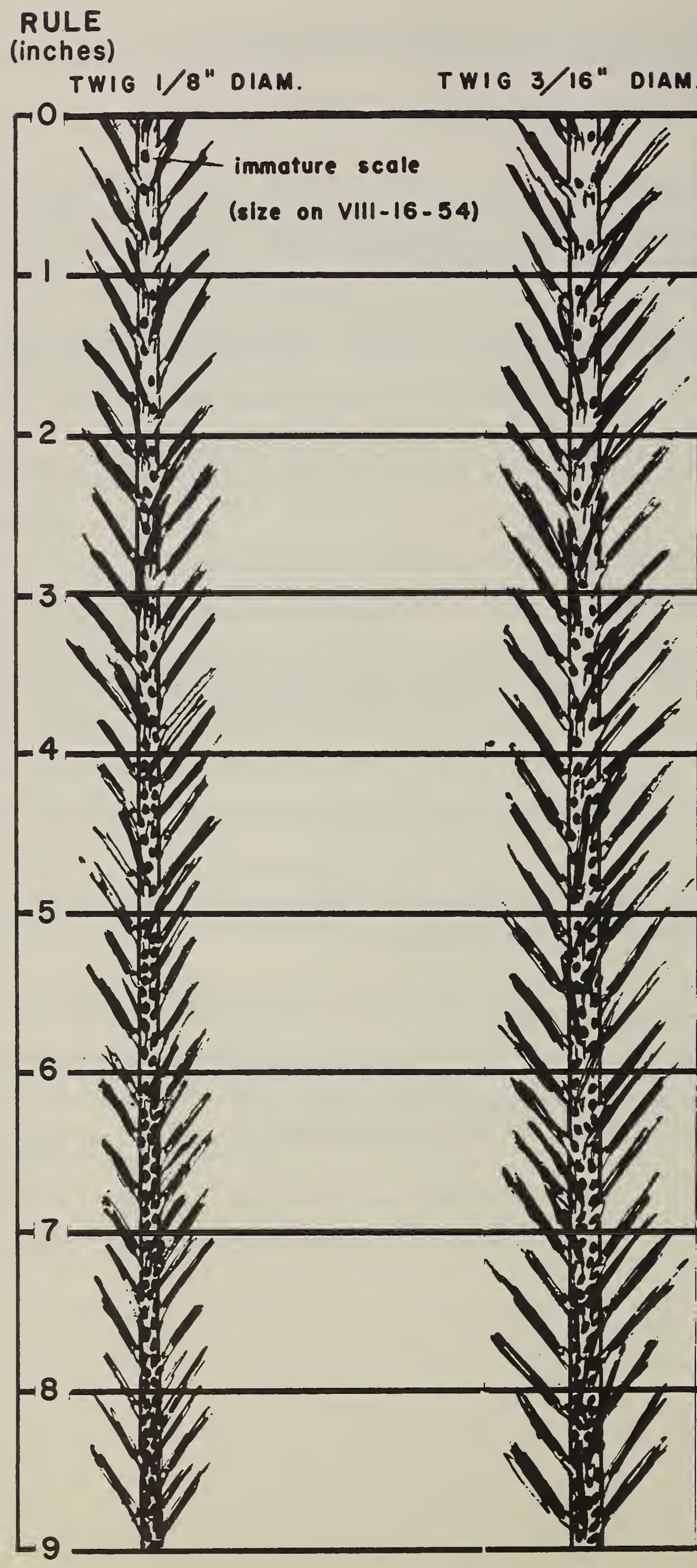
17. Record in remarks column any abnormal condition of trees, or any insects noticed between sample points.



Materials Required for Survey of Pine Tortoise Scale

1. Pole pruners (5' aluminum sections 2-1/2 feet cutting head).
2. Mimeographed survey form.
3. Table to show appearance of immature scales.
4. Mimeographed map of plantation.
5. Spring-back aluminum binder for holding forms.
   (R. D. Shenefelt and P. A. Jones, University of Wisconsin).

STANDARD FOR ESTIMATING NUMBER OF PINE TORTOISE SCALE PER LINEAR INCH



COLUMN 1 No. Scales Actually Observed	COLUMN 2 No. Scales Per Inch Of New Growth
3	5
5	10
7	15
10	20
12	25
15	30
18	35
20	40
OVER 22	OVER 45

PINE TORTOISE SCALE SURVEY SHEET

Date__________ Plantation name__________ Recorder__________
T__________ R__________ S__________ 40__________ Strip started on__________ to__________
Strip #__________ Direction traveled on strip__________ to__________
County__________ Plantation worked from__________

Tree No.	TOP Number of immature scales per inch of new growth										Length of new growth in inches	MIDDLE Number of immature scales per inch of new growth										Length of new growth in inches	DAMAGE					Predator population on new growth	Tree height	% dead trees	REMARKS
	0	5	10	15	20	25	30	35	40	45		0	5	10	15	20	25	30	35	40	45		% branches dead	% tips dead	% red needles	Will tree survive	No evident damage				
1																															
2																															
3																															
4																															
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UNIFORM SURVEY PROCEDURE APPROVED BY
THE LAKE STATES FOREST INSECT SURVEY COMMITTEE - 1956

FOREST TENT CATERPILLAR APPRAISAL SURVEYS

PURPOSE:

The forest tent caterpillar has been a vigorous defoliator of aspen and other broadleafed trees throughout hardwood forest areas of the Lake States. While defoliation resulting from periodic caterpillar outbreaks is spectacular in nature, the amount of mortality caused to susceptible host trees generally is not enough to warrant the initiation of large scale chemical control. However, the ever-increasing value of forested areas for wild life and recreational purposes magnifies the seriousness of such infestations. The presence of thousands of caterpillar larvae becomes a real nuisance to inhabitants of affected areas. Direct monetary loss to the resort and tourist industries was sufficient to warrant an action program in most wooded areas in Minnesota from 1950 through 1955.

Predicting the location and severity of infestations and recommending subsequent control measures must be based upon a sound appraisal of infestations. The coordinated efforts of all state, federal, civic, and commercial groups concerned with the caterpillar are necessary for maximum effectiveness. Because infestations may become widespread in distribution, vast savings can be made by utilizing foresters or other personnel already stationed in the field to collect and report survey data. The procedures discussed here will provide sufficient data to predict accurately the status of infestations for use in recommending control. They may furnish others with the facts and procedures necessary for an understanding of the behavior and characteristics of forest tent caterpillar. These procedures have been substantiated by research and were used successfully during the recent outbreak in Minnesota. The four main procedures that were used annually in order to measure populations are:

A. Defoliation surveys. --Determining degree and extent of defoliation.

B. Cocoon surveys. --Determining density of cocoon populations.

C. Egg mass surveys. --Determining abundance of egg masses.

D. Seasonal development surveys. --Time of hatching, time of maximum control effectiveness.

The following life history table covers each stage as it is likely to occur under Minnesota conditions.

Eggs:	Hatch April 15-May 15
Larvae:	April 15-June 15
Pupae:	June 15-July 10
Adult:	June 25-July 20

A. Surveys to determine degree and extent of defoliation

A rapid and useful picture of the current overall distribution of forest tent caterpillar can be made at a time when the insect or its consequences are most conspicuous. Besides delimiting the infestation, the relative population levels throughout an infested area can be determined by measuring specific degrees of defoliation. Generally both aerial and ground procedures are necessary in order to gain a complete picture. This does not, however, provide sufficient information for use in predicting the trend of infestations because the effects of starvation and parasitism are not apparent as a result of such surveys. Reconnaissance should be made after larval feeding has passed its peak, but before refoliation of the stripped trees becomes evident. Where large forest expanses are involved, north-south differences in development may make it necessary to stagger dates of observation.

1. Ground reconnaissance

Estimates of specific defoliation levels can be determined more accurately by ground rather than from aerial observations. A measure of the relative abundance of caterpillar populations can be made by recording the condition of host trees at locations scattered

throughout an infested area. In the fall the amount of actual feeding that occurred the past summer can be more closely related to the probable larval population if defoliation records are taken at the same locations where egg mass counts were made the previous fall. This also provides some indication of the amount of larval mortality that occurred during hatching and early instars.

So that the degree of defoliation may be quickly assessed over thousands or millions of infested acres, non-technical personnel already stationed in the field are requested to report conditions in their immediate area. A simple survey form for estimating and reporting defoliation is shown below. When completed forms are received, the information is transferred to a large map, using convenient symbols to show the defoliation level at each location.

FOREST TENT CATERPILLAR
DEFOLIATION REPORT

INSTRUCTIONS FOR COMPILING

Designation

Heavy: From complete stripping of all broadleafed trees and brush (except red maple and sumac which are not fed upon) to complete defoliation of aspen or oak with conspicuous feeding damage on birch and brush.

Moderate: Occasional aspen and oak completely stripped, most aspen and oak with tops thin; little feeding on birch or brush.

Light: No trees showing complete defoliation. Feeding damage confined to top of the aspen and oak crowns. Little or no feeding on other tree or brush species.

None: No leaves removed from crown of any tree species. Terminal branches with normal foliage (caterpillars may be present in small numbers, but no conspicuous signs of feeding).

Note: Do not allow presence or absence of larvae to influence defoliation estimates. The purpose of this survey is to relate actual feeding damage to egg mass abundance data which you collected last fall. Please use separate sheet for each locality. A prompt estimate of defoliation and return of this form will be appreciated because this information is necessary for planning an aerial survey.

Date________________

Forest________________ District________________ Observer________________

Locality Amount of defoliation

S.______ T.______ R.______ ____________________

Comments:________________________________

2. Aerial reconnaissance

Aerial observations are used to map the overall distribution of caterpillar by delimiting areas of defoliation and noting comparative severity. The fine degrees of defoliation used in ground reconnaissance cannot be determined accurately from the air, unless frequent re-checks are made to study locations with known degrees of defoliation. Generally only two main categories of defoliation level are necessary for aerial reconnaissance.

HEAVY -- Areas where most of the trees show complete stripping of leaves, same as heavy on ground survey report form.

PARTIAL -- Areas where defoliation is noticeable, but trees are not completely stripped of leaves. Combining light and moderate defoliation levels.

The procedure used to map defoliation is as follows:

1. Using Regional navigational maps, or others, that show good landmark points, draw flight lines at 6-or 12 mile intervals covering the infested area. Mark three maps, one for pilot, and one for each observer.

2. The flight intervals and altitude are dependent on two sets of conditions.

   a. Where heavy defoliation appears to be general over a large area, fly 12-mile intervals as an altitude of 1, 500 feet, and observers can usually note conditions for about 6 miles on either side of the plant.

   b. Where spotty or partial defoliation occurs fly 6-mile intervals at an altitude of 1, 000 feet and observers can determine conditions for 3 miles on either side of the plane.

3. Using a plane that will accommodate the pilot and two observers, systematically follow flight lines on the previously marked maps.

4. Note the general condition of broadleafed trees over each mile of territory covered, continually checking landmarks so that the position is always known.

5. Mark observed levels of defoliation on the corresponding position of the flight maps. Suggested colors for marking are:

   RED - To denote heavy defoliation.
   BLUE - To denote partial defoliation.

   Shading colors may be desirable wnere defoliation is extremely variable or if borderline conditions make determinations difficult. Where operation recorders are available they may be used to continuous strip sampling in lieu of area coloring as described above.

B. Cocoon survey

Knowledge of the abundance and condition of forest tent caterpillar cocoons is a useful index of the surviving caterpillar population. It also measures the extent of the late larval and cocoon parasitism (principally by Sarcophaga aldrichi), which may help to terminate the outbreak. Such information can be gained by counting the numbers of collected cocoons in a given time and then examining them for signs of parasitism or other destruction. It is suggested that collections be made at locations where egg mass counts and defoliation estimates were previously made in order to tie in the entire picture of caterpillar progress. Adequate coverage, by selecting these sampling stations based on an area-wide infestation, will yield a balanced picture of parasitism.

The cocoon survey can be made in the selected aspen or hardwood type stands after most of the moths have emerged. Again, because of the large area to be covered, nontechnical personnel can make the actual collections in the field and send them to a central laboratory for examination. A sample request, outlining the procedure used, is shown here.

FOREST TENT CATERPILLAR COCOON SURVEY

Attached are locality descriptions of your area which correspond to roadside locations at or near which we would like to have cocoon collections made. The selection of these sampling stations is based upon the state-wide infestation, and is intended to yield a balanced picture of parasitism in the entire area. Try to make your collections as near as possible to the sites where egg collections and defoliation estimates were made.

We are interested in both time and quantity cocoon collections. It is requested that the collector first make a three-minute collection of cocoons on the brush, beginning at a point 5 to 10 yards from the forest edge. We would prefer that this collection be made over a distance of at least 1 chain (66ft.) rather than confining all collecting to one or several branches or bushes. This is best accomplished if the collector maintains a moderate walking speed throughout the three-minute collecting period. At the end of the three-minute period, the observer should make an estimate of the number of cocoons that he has collected. Should he have fewer than 15 cocoons, it is requested that he collect for an additional 1, 2, or 3 three-minute interval up to a maximum of 12 minutes, in order to increase the size of the sample. The collection should be placed in a paper bag with the exact location and the duration of the collection time marked thereon. It is important to have both the legal description of the collection site and the length of the collecting time clearly marked on the paper bag.

The collection should be made after most of the moths have emerged. In some cases, no cocoons will be found after prolonged searching. Where this occurs, please indicate the location, time spent collecting, and the fact that no cocoons were found.

The following criteria can be used to determine the condition of cocoons:

1. Normal healthy moths emerged from silken cocoons that appear light yellow brown around the exit hole. The pupal skins within are usually dry and fragile.

2. Parasitized cocoons show dark staining around one end, and the pupal skin is greasy and tougher in texture.

The number of cocoons per unit area of ground vegetation varies greatly with (1) the size of the caterpillar population, (2) the degree of defoliation, and (3) the amount of caterpillar wandering. The vertical positioning of cocoons usually reflects the level of defoliation. For example, where light to moderate defoliation has occurred, most of the cocoons will be found in leaves of deciduous trees. Where complete defoliation has occurred the cocoons will all be found on ground vegetation, such as bracken fern and others, and there will be few, if any, in deciduous trees, excepting red maple. Principal chances for error in collecting cocoons on brush occur when populations are very large or extremely small and when the brush is irregular and not uniformly spaced. As an example, where 70 or more cocoons are found per square meter the collector cannot pick fast enough to indicate the difference between 50 or 80. However, such large numbers indicate extremely high populations and for practical purposes the differences do not matter.

In spite of these limitations, this survey provides useful information such as: (1) an accurate representation of successful moth emergence, and (2) how parasitism is progressing. Until 90 percent or more cocoons are affected, parasitism is seldom of major importance except where populations have been drastically reduced by starvation.

C. Egg mass survey

An egg mass survey is the most important measurement for predicting the area and intensity of the subsequent year's infestation. Eggs representing reproductive efforts of currently emerged moths are final indicators of the probable caterpillar population and subsequent level of defoliation. In order to determine these predictions, it is necessary to know how many viable eggs are present on individual trees throughout the area. Embryos are well developed within the eggs by early fall, and parasitized or diseased eggs can be distinguished readily in late fall.

1. Procedure for collecting egg masses

To accomplish this survey, requests can again be sent to cooperators in the field.

FOREST TENT CATERPILLAR
EGG MASS COLLECTION

1. Cut representative aspen trees within a 1/5-acre area at the location selected. The trees should be typical of the stand, particularly with respect to crown size.

2. Examine the twigs of each crown carefully for the presence of tent caterpillar egg masses.

3. Collect all egg masses (whether old or new) from each tree and place in a separate container (paper bag, box, etc.). Identify each tree collection with Section, Township, and Range designations. The three collections from each station should then be placed in a single container and suitably marked.

4. Clearly mark on each bag containing egg masses, the d. b. h. of tree which was sampled.

A sequential sampling system for egg mass surveys has not been worked out for conditions in this region, although it is felt that such a system could be developed. To avoid cutting trees, other methods, such as estimating the number of egg masses with binoculars, have been tried. The results were inaccurate. Nevertheless, in parks, cities, and communities where cutting cannot be used, estimates will have to be made on small trees or with the use of binoculars.

2. Predicting probable caterpillar populations and subsequent level of defoliation

For accurate predicting of caterpillar populations it is necessary to anticipate the number of living larvae per tree fairly accurately; correlate these figures with the amount of foliage each larva can consume and with the number of leaves present. The size of trees, amount of foliage, and the number of stems per acre will greatly influence interpretation of egg mass counts. In

addition , there may be extreme variation of counts from tree to tree within a stand. However, sufficient sampling will show an average or trend throughout the area.

The following categories are used to relate egg mass abundance to the amount of defoliation expected.

Average number of masses per tree	Expected level of defoliation
0 - 4	Light
5 - 9	Moderate
10 - 14	Moderate to heavy
15 - more	Heavy to complete

The basis for these categories, as well as a more complete discussion on egg mass collections and prediction methods, is given in the University Agricultural Experiment Station Technical Bulletin 148 by A. C. Hodson.

When egg mass counts are assembled, mapped, and expressed as defoliation potential, a prediction map is drawn and duplicated for distribution to all interested groups or individuals. This will enable those in any given area of the state to anticipate the extent of caterpillar infestationforthe ensuing year.

A high percent of egg, or embryonic, mortality during late fall and winter can greatly reduce the seriousness of infestation. The amount of mortality can be determined during April by carefully slicing the tops from three rows of eggs on opposite sides of a mass and then counting the number of healthy and the number of dead or diseased eggs. Sixty egg masses picked at random from any one site will give a reliable figure.

D. Survey to determine time of egg hatching

In a situation where commercial operators must be relied upon to make contact with resort owners and municipalities who wish to control forest tent caterpillars, it may be necessary to publicize the appropriate time for applying chemicals and insecticides. Since the later stages of the forest tent caterpillar epidemic covered a vast area and the seasonal variation was considerable, it was particularly valuable to have timely reports of development from all over the infested area.

Entomologists must be in field at least 2 weeks prior to egg hatching. In addition, forester observers, who are distributed over the entire forested area, may submit reports of phenological phenomena that preceded caterpillar hatching. A supply of self-addressed post cards was mailed to each observer and he was requested to check each of 22 phenomena as they occurred and send the post card at the time of checking. As a result, each observer mailed some 22 post cards to the coordinating office. When cards from all over the state were tabulated, a reasonably good picture of seasonal variations was apparent.

Timely news releases, based on the reports of entomologists and cooperators, were prepared prior to and during the control period. In addition to circular letters, the newspapers, radio, and television were also employed where they could best serve to inform the public. In this way, both commercial spray operators and property owners depending on effective control were given necessary assistance.

J. W. Butcher, Minnesota State Entomology Dept. and A. C. Hodson, University of Minnesota.

Uniform Survey Procedure Approved By
The Lake States Forest Insect Survey Committee - 1956

JACK-PINE BUDWORM SURVEYS

PURPOSE:

The jack-pine budworm, Choristoneura pinus Freeman, is a serious problem in natural jack pine stands throughout the Lake States. Since its identification in 1923, it has caused the mortality of substantial volumes of merchantable jack pine and vast numbers of sapling and reproduction jack, red, and white pine growing in the understory. Outbreaks of this insect occur periodically at intervals of from 6 to 8 years and last for 2 to 4 years.

During the recent (1949-1952) budworm outbreak in the Lower Peninsula of Michigan, survey techniques were developed by the U. S. Bureau of Entomology and Plant Quarantine in cooperation with the Forest Service and the Michigan Conservation Department, for evaluating the infestation. Inasmuch as the insect was widely distributed and present in varying degrees of intensity throughout the jack-pine type, surveys to detect its presence or absence were not deemed necessary. Procedures to appraise the seriousness of infestations and to estimate loss of the forest resource were designed and field tested. The methods and procedures found satisfactory are presented here.

INSTRUCTIONS:

Appraisal Survey

Appraisals of the seriousness of known jack-pine budworm infestations in Michigan and Wisconsin are conducted after defoliation is completed and before the damage (clipped) foliage has fallen from the trees. The following procedure is designed to enable the rapid evaluation of an infestation over a rather large area in a minimum of time. No attempt is made to collect information relative to stand composition or site quality.

A series of temporary roadside observation stations each located in jack-pine type at intervals of approximately 1 mile along the major transportation routes throughout the infestation area are established. The severity of budworm defoliation of the general stand is estimated at or beyond 200 feet from the road right-of-way. Criteria of defoliation employed are as follows:

1. None - No budworm defoliation evident on trees or reproduction. Crowns of canopy green. No budworm cast pupal skins on trees or reproduction.

2. Light - No budworm defoliation evident, or barely evident on trees. Crowns of canopy green.. Budworm defoliation evident on understory reproduction. Leaders and laterals of understory trees not webbed together. Budworm cast pupal skins present on trees or reproduction.

3. Medium - Budworm defoliation evident on trees. Crowns of canopy predominantly green but with brownish to reddish background. Defoliation of understory reproduction evident. Leaders and laterals of understory trees webbed together. Cast pupal skins present on trees and understory reproduction.

4. Heavy - Budworm defoliation evident on trees to complete defoliation. Crowns of canopy predominantly reddish brown. Budworm defoliation of understory reproduction severe to complete. Leaders and laterals of understory trees webbed together. Cast pupal skins present on trees and understory reproduction.

The survey form below will be used to record the necessary data at each observation station.

The stations will be numbered consecutively and the mileage or distance from a landmark noted. Each station will be located by township, range, and section, and, if possible, by quarter section.

The degree of overstory and understory defoliation should be estimated and the presence of lateral-terminal webbing and cast pupal skins noted. The severity of general infestation should also be noted. Any other observations on stand conditions, etc., can be made in the space provided for remarks at the botton of the form.

A narrative report, summarizing the findings of the survey, will include the methods employed, a map indicating categories of defoliation severity by acreages, and general conclusions and recommendations.

JACK-PINE BUDWORM - DEFOLIATION APPRAISAL SURVEY

Station number	Mileage from landmark	Location				Overstory defoliation				Understory defoliation					Cast pupal skins		Severity of infestation			
		T	R	S	Q	N	L	M	H	N	L	M	H	L-T webbing	Understory	Overstory	N	L	M	H

Remarks:

Aerial Surveys

An evaluation of jack-pine budworm infestations from the air is conducted by examining infestations along predetermined flight lines established at uniform intervals of from 1 to 12 miles. Random or meandering flights along the boundary of known infestations also are used in aerial surveys. The operation recorder probably would be of material help for use in recording infestations in this region from the air.

In the conduct of the aerial survey for the jack-pine budworm the following steps are taken:

1. Areas of known infestation intensity are located on the ground and flown over to acquaint observers with known intensity of budworm defoliation.

2. Criteria of abundance employed.

    a. None-light - No defoliation evident. Crowns normal green.

b. Medium - Defoliation evident. Crowns predominantly green with brownish background.

c. Heavy - Defoliation evident. Crowns predominantly reddish brown.

3. Airplane. A single-engine, high-wing airplane, such as the Cessna 170-B or Cessna 180, gives very satisfactory performance, with ample room for two observers. The flight lines should be 1 - to 12 - mile grids, along north-south or east-west lines, and the altitude should be 500 to 1,000 feet.

4. Mapping. County, Highway, Cover Type, or Aerial Navigation maps can be used--a scale of 1/2 inch or 1 inch per mile is preferable, if available. The general location of defoliation can be sketched in by foregoing criteria.

5. Report. This should be incorporated with a ground survey.

Timber Drain Survey

An appraisal of the loss of timber caused by budworm feeding in Michigan and Wisconsin is conducted after defoliation is completed, generally in mid-August, or early September. The following general procedure is followed:

1. The area of infestation is determined from reconnaissance survey maps and the area of each category of severity of defoliation is computed.

2. The number of evaluation plots required is determined from the Intensity of Sampling statement prepared for the Lake States Forest Insect Survey Committee (see CEIR 6(28):675). This number is based on the standard of accuracy required, the density and uniformity of the stand, the value of the stand, and the acreage to be sampled.

3. Plot location and procedure.

   a. Two or three men will comprise a crew. Note the mileage from a definite landmark: river, crossroad, or estimated distance if cruising or walking. If the survey is conducted by road the plots should be approximately 5 chains from the road right-of-way.

   b. The plots should be 1/5 acre, with a convenient tree as the center. Plot examination should be by sectors, using two plastic ropes, each 52.7 feet long. Tree diameter will be taken by diameter tape or cruiser's stick. The number of logs can be determined by cruiser's stick or by estimation. Reproduction can be determined by actual tally.

4. Tree tally. Using the Cumulative Tree Tally Form 99-R9 (Rev. 6/17/47) record trees by species and diameter class--2-inch saplings, 4-inch saplings, 6-inch and over merchantable poles, and reproduction. A record of the health class should also be made by (a) living, (b) dead - budworm killed, and (c) dead - (suppressed) budworm killed).

5. A summary report should be prepared to show methods employed, area surveyed, summary of losses, general conclusions, and recommendations and predictions.

D. M. Benjamin, University of Wisconsin

Form 99 R-9

DBH					
2"					
4"					

CUMULATIVE 1/5. ACRE TALLY SHEET

ESTIMATOR ______ DATE ______

COURSE ______ PLOT ______ SEC. ______ T. ______ R. ______

MAP TYPE

PLOT TYPE

VOLUME IN TENTHS OF CORDS PER ACRE

NUMBER OF 8-FOOT BOLTS (4" OR LARGER) PER TREE

DBH	SPEC. & LEGEND	NON-MERCH.	1	2	3	4	5	6	7
6			1 2 3 4 5 6 6 7 8 9 10 11 12 13 14 15 16 17 18 18 19 20 21 22 23 24 25 26 27	1 3 4 6 7 9 10 12 13 15 16 18 19 21 22 24 25 27 28 30 31 33 34 36 37 39 40 42 43 45 46 48 49 51 52	2 4 6 9 11 13 15 17 19 22 24 26 28 30 32 35 37 39 41 43 45 48 50 52 54 56 58 60 63 65 67 69 71 73 76 78 80	3 6 9 12 14 17 20 23 26 29 32 35 37 40 43 46 49 52 55 58 60 63 66			
			1 2 3 4 5 6 6 7 8 9 10 11 12 13 14 15 16 17 18 18 19	1 3 4 6 7 9 10 12 13 15 16 18 19 21 22 24 25 27 28 30 31 33 34 36 37 39	2 4 6 9 11 13 15 17 19 22 24 26 28 30 32 35 37 39 41 43 45 48 50 52 54 56 58 60	3 6 9 12 14 17 20 23 26 29 32 35 37 40 43 46 49 52 55 58 60			
			1 2 3 4 5 6 6 7 8 9 10 11 12 13	1 3 4 6 7 9 10 12 13 15 16 18 19 21 22 24 25 27	2 4 6 9 11 13 15 17 19 22 24 26 28 30 32 35 37	3 6 9 12 14 17 20 23 26 29 32 35 37 40 43 46			
			1 2 3 4 5 6 6 7 8 9 10 11 12 13	1 3 4 6 7 9 10 12 13 15 16 18 19 21 22 24 25 27	2 4 6 9 11 13 15 17 19 22 24 26 28 30 32 35 37	3 6 9 12 14 17 20 23 26 29 32 35 37 40 43 46 49			
8			2 3 5 6 8 10 11 13 14 16 18 19 21 22 24 26 27 29 30	2 5 7 10 12 15 17 20 22 25 27 30 32 35 37 40 42 45 47 50 52 55 57 60 62 64 67 69 72 74	3 7 10 14 17 21 24 28 31 35 38 42 45 49 52 56 60 63 66 70 73 77 80 84 87 91 94 98 101 105 108	5 9 14 18 23 28 32 37 41 46 51 55 60 65 69 74 78 83 88 92 97 101 106 111 115 120 124 129 134 138	6 12 17 23 29 35 41 46 52 58 64 70 75 81	7 14 21 28 34 41 48 55 62 69	
			2 3 5 6 8 10 11 13 14 16 18 19 21 22	2 5 7 10 12 15 17 20 22 25 27 30 32 35 37 40 42 45 47 50 52 55	3 7 10 14 17 21 24 28 31 35 38 42 45 49 52 56 60 63 66 70 73 77 80 84	5 9 14 18 23 28 32 37 41 46 51 55 60 65 69 74 78 83 88 92 97 101 106 111	6 12 17 23 29 35 41 46 52 58 64 70	7 14 21 28 34 41 48 55 62	
			2 3 5 6 8 10 11 13	2 5 7 10 12 15 17 20 22 25 27 30 32 35 37	3 7 10 14 17 21 24 28 31 35 38 42 45 49 52 56	5 9 14 18 23 28 32 37 41 46 51 55 60 65 69 74	6 12 17 23 29 35 41 46 52 58	7 14 21 28 34 41 48 55	
			2 3 5 6 8 10 11 13	2 5 7 10 12 15 17 20 22 25 27 30 32 35	3 7 10 14 17 21 24 28 31 35 38 42 45 49 52	5 9 14 18 23 28 32 37 41 46 51 55 60 65 69 74	6 12 17 23 29 35 41 46 52 58	7 14 21 28 34 41 48 55	
10			2 5 7 10 12 15 17 20 22 25	4 7 11 15 18 22 26 29 33 37 40 44 48 51 55 59 62 66 70	5 10 15 20 25 30 35 41 46 51 56 61 66 71 76 81 86 91 96 101 106	7 13 20 26 33 40 46 53 59 66 73 79 86 92 99 106 112 119 126 132 139 145	8 17 25 33 42 50 58 67 75 83 92 100 109 117	10 20 30 40 50 60 70 80 90 100 110 120 130 140	12 24 36 48 60 72 84 96 108 120 132
			2 5 7 10 12 15	4 7 11 15 18 22 26 29 33 37 40 44 48	5 10 15 20 25 30 35 41 46 51 56 61 66 71	7 13 20 26 33 40 46 53 59 66 73 79 86 92 99 106	8 17 25 33 42 50 58 67 75 83	10 20 30 40 50 60 70 80 90 100	12 24 36 48 60 72 84 96
			2 5 7 10 12	4 7 11 15 18 22 26 29 33 37 40 44 48	5 10 15 20 25 30 35 41 46 51 56 61 66 71	7 13 20 26 33 40 46 53 59 66 73 79 86 92 99 106	8 17 25 33 42 50 58 67 75 83 92 100	10 20 30 40 50 60 70 80 90 100 110	12 24 36 48 60 72 84 96
			2 5 7	4 7 11 15 18 22	5 10 15 20 25 30 35	7 13 20 26 33 40 46 53	8 17 25 33 42 50	10 20 30 40 50 60	12 24 36 48

MORTALITY / ACRE

NO. TREES 2"	NO. TREES 4"	VOL. BY SPECIES SPEC.	CDS.	BD.FT.

AVERAGE PERCENT DEFECT

POLES

TOTALS PER ACRE

TOT. CORDS

VOLUME IN HUNDREDS OF BOARD FEET (SCRIBNER) PER ACRE

NUMBER OF 16-FOOT LOGS (8" OR LARGER) PER TREE

DBH	SPEC. & LEGEND	NON-MERCH.	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5
10			1 1 2 3 3 4 5 6 6 7 8 8 9 10 11 11 12 13 13 14 15 15 16 17	2 3 4 6 7 9 10 12 13 15 16 18 19 21 22 24 25 27 28 30 31 33 34 36 37 39 40 42 43 45	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58							
			1 1 2 3 3 4 5 6 6 7 8 8 9 10 11 11 12 13 13	2 3 4 6 7 9 10 12 13 15 16 18 19 21 22 24 25 27 28 30 31 33 34	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44							
			1 1 2 3 3 4 5 6 6 7 8 8 9	2 3 4 6 7 9 10 12 13 15 16 18 19 21 22	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30							
			1 1 2 3 3 4 5	2 3 4 6 7 9 10 12	2 4 6 8 10 12 14 16							
12			1 3 4 6 7 8 10 11 13 14 15 17 18 20 21 22 24 25	2 5 7 10 12 14 17 19 22 24 29 29 31 34 36 38 41 43 46 48 50 53 55 58 60 62 65 67 70	3 7 10 13 16 20 23 26 30 33 36 40 43 46 50 53 56 59 63 66 69 73 76 79 82 86 89 92	4 8 12 16 20 23 27 31 35 39 43 47 51 55 58 62 66 70 74 78 82 86 90 94	5 10 15 19 24 29 34 39 44 48 53 58 63 68 73 78					
			1 3 4 6 7 8 10 11 13 14 15 17 18 20	2 5 7 10 12 14 17 19 22 24 29 29 31 34 36 38 41 43 46 48	3 7 10 13 16 20 23 26 30 33 36 40 43 46 50 53 56 59 63	4 8 12 16 20 23 27 31 35 39 43 47 51 55 58 62 66 70	5 10 15 19 24 29 34 39 44 48 53 58					
			1 3 4 6 7 8 10 11 13 14	2 5 7 10 12 14 17 19 22 24 29 29 31 34	3 7 10 13 16 20 23 26 30 33 36 40 43	4 8 12 16 20 23 27 31 35 39 43 47	5 10 15 19 24 29 34 39					
			1 3 4 6 7 8	2 5 7 10 12 14 17 19	3 7 10 13 16 20 23	4 8 12 16 20 23	5 10 15 19 24					
14			2 4 6 8 10 12 14 16 18 20 22 24 26 28	4 7 10 14 18 21 24 28 32 35 38 42 46 49 52 56 60 63 66	5 10 14 19 24 29 34 38 43 48 53 58 62 67 72 77 82 86 91	6 12 17 23 29 35 41 46 52 58 64 70 75 81 87 93 99	7 14 21 28 35 42 49 56 63 70 78 85	8 16 25 33 41 50 58 66 74 82	9 19 28 38 47 57			
			2 4 6 8 10 12 14 16 18 20	4 7 10 14 18 21 24 28 32 35 38 42 46	5 10 14 19 24 29 34 38 43 48 53 58 62	6 12 17 23 29 35 41 46 52 58 64 70	7 14 21 28 35 42 49 56	8 16 25 33 41 50 58 66	9 19 28 38			
			2 4 6 8 10 12 14 16 18	4 7 10 14 18 21 24 28 32 35 38 42 46	5 10 14 19 24 29 34 38 43 48 53 58 62	6 12 17 23 29 35 41 46 52 58 64 70	7 14 21 28 35 42 49 56	8 16 25 33 41 50 58 66	9 19 28 38			
			2 4 6 8 10	4 7 10 14 18 21 24	5 10 14 19 24 29 34	6 12 17 23 29 35	7 14 21 28	8 16 25 33	9 19			
16			3 5 8 11 14 16 19 22 24	5 9 14 19 23 28 33 37 42 46 51 56	6 13 19 26 32 39 45 52 58 64 71 77	8 15 24 32 40 47 55 63 71 79 87 95	10 19 29 38 48 57 67 76	11 22 34 45 56 67 78 90	13 25 38 50	14 28 42 56		
			3 5 8 11 14 16 19 22 24	5 9 14 19 23 28 33 37 42 46 51 56	6 13 19 26 32 39 45 52 58 64 71 77	8 15 24 32 40 47 55 63 71 79 87 95	10 19 29 38 48 57 67 76	11 22 34 45 56 67 78 90	13 25 38 50	14 28 42 56		
			3 5 8 11 14	5 9 14 19 23 28	6 13 19 26 32 39	8 15 24 32 40 47	10 19 29 38	11 22 34 45	13 25	14 28		
			3 5 8 11 14	5 9 14 19 23 28	6 13 19 26 32 39	8 15 24 32 40 47	10 19 29 38	11 22 34 45	13 25	14 28		
18			4 7 11 14 18 22 25	6 12 18 24 30 37 43 49 55 61 69	8 17 25 34 42 50 59 67 76 84 92	10 21 31 41 52 62 72 83 93 104 114	12 25 37 50 62 74 87 99	15 29 44 58 73 88 102	16 32 48 65	18 36 53 71		
			4 7 11 14	6 12 18 24 30 37	8 17 25 34 42 50	10 21 31 41 52 62	12 25 37 50	15 29 44 58	16 32	18 36		
			4 7 11 14	6 12 18 24 30 37	8 17 25 34 42 50	10 21 31 41 52 62	12 25 37 50	15 29 44 58	16 32	18 36		
			4 7 11 14	6 12 18 24 30 37	8 17 25 34 42 50	10 21 31 41 52 62	12 25 37 50	15 29 44 58	16 32	18 36		
20			4 9 14 18 22 27 32	8 16 23 31 39 47 55 62 70 78 86	11 21 32 42 53 64 74 85 95 106 117	13 26 39 52 66 79 92 105 118 131 144	16 32 48 63 79 95 111 127 143	18 37 55 73 92 110 128	20 41 61 81	23 45 68 90	25 50 75 100	27
			4 9 14 18	8 16 23 31 39 47	11 21 32 42 53 64	13 26 39 52 66 79	16 32 48 63 79	18 37 55 73	20 41	23 45	25 50	27
			4 9 14 18	8 16 23 31 39 47	11 21 32 42 53 64	13 26 39 52 66 79	16 32 42 63 79	18 37 55 73	20 41	23 45	25 50	27
			4 9 14 18	8 16 23 31 39	11 21 32 42 53 64	13 26 39 52 66 79	16 32 42 63 79	18 37 55 73	20 41	23 45	25 50	27
22			6 11 17 22	10 19 29 39 48	13 26 39 52 66	16 33 49 66 82 98	20 39 59 78	23 45 68 90	25 50	28 56	31 62	33
			6 11 17 22	10 19 29 39 48	13 26 39 52 66	16 33 49 66 82 98	20 39 59 78	23 45 68 90	25 50	28 56	31 62	33
			6 11 17 22	10 19 29 39 48	13 26 39 52 66	16 33 49 66 82 98	20 39 59 78	23 45 68 90	25 50	28 56	31 62	33
24			7 14 21	12 24 35 47 59	16 32 48 64 80	20 40 60 80 100	24 47 71 94	27 55 82 110	31 61	34 69	38 75	41
			7 14 21	12 24 35 47 59	16 32 48 64 80	20 40 60 80 100	24 47 71 94	27 55 82 110	31 61	34 69	38 75	41
			7 14 21	12 24 35 47 59	16 32 48 64 80	20 40 60 80 100	24 47 71 94	24 55 82 110	31 61	34 69	38 75	41
26			8 16 25	14 28 42 56 70	19 38 57 76 95	24 48 72 96 120 143	28 57 85 113	33 65 98 131	36 73	41 82	45 90	49
			8 16 25	14 28 42 56 70	19 38 57 76 95	24 48 72 96 120 143	28 57 85 113	33 65 98 131	36 73	41 82	45 90	49
28			10 20 29	17 33 50 66	22 45 67 90 112	28 55 84 112 140 168	33 66 100 133	38 76 115 153	43 86	48 96	53	57
			10 20 29	17 33 50 66	22 45 67 90 112	28 55 84 112 140 168	33 66 100 133	38 76 115 153	43 86	48 96	53	57
30			11 23 34	19 38 57 77	26 52 78 104	32 65 97 130 162	39 77 116 154	44 89 133 177	50 100	56 111	61	67
			11 23 34	19 38 57 77	26 52 78 104	32 65 97 130 162	39 77 116 154	44 89 133 177	50 100	56 111	61	67
32			13 26 39	22 44 66 88	30 60 90 120	37 75 112 149 186	44 89 133 178	51 102 153 204	57 114	64 128	71	78
			13 26 39	22 44 66 88	30 60 90 120	37 75 112 149 186	44 89 133 178	51 102 153 204	57 114	64 128	71	78
34			15 29	25 50 75 100	34 68 102 136	42 85 127 169 212 254	50 101 151 202	58 116 174 232	65 129	73 146	81	89
36			16 33	28 56 85 113	38 77 115 153	48 96 143 191 239	57 114 170 227	65 131 196 261	73 146	82 164	92	101
38			18 36	32 63 95 127	43 86 128 171	53 107 160 214 267	63 127 190 254	73 146 219 293	82 164	92 184	103	115
40			20 40	35 70 105	48 95 143 190	59 118 177 237 296	70 141 211 281	82 163 245 326	91 182	103 205	116	129
42			22 44	39 78 117 155	53 106 158 211	65 130 196 261 326	78 155 232 310	90 180 270 360	101 202	113 225	129	145

RECOMMENDED CUT (NET) / ACRE

TYPE OF CUT	PERIOD	SPEC.	CORD	M BD. FT.
IMPROVEMENT				
SALVAGE				
ROTATION				
TOTAL				

TOTAL NET VOLUME

SPECIES	CORDS	M.BD.FT.

AVERAGE PERCENT DEFECT

SAWTIMBER

Form 99 R-9 Continued

CEDAR TALLY

D. B. H.	7' Posts	8' Ties	Poles							Shingle Bolts
			20'	25'	30'	35'	40'	45'	50'	
6										
8										
10										
12										
14										
16										
18										
20										
22										
24										

SAMPLE TREE DATA

Tree No.	Dist. & bearing to tree	Spec.	DBH	Height		Tree Class	Age	Radial Gr.		Defect %
				Total	Merch			10 Yr.	20 Yr.	

Site Classification ______________________ Operability ____________________________

*Supplementary Cruise Data

Type acreage ______________ Cruise % ______________ % Accuracy ______________

Stand Description ____

Logging chance. Easy____ Medium___Difficult___Winter___Summer____Yearlong_______

Accessibility: Miles of road to construct _____________ Total road cost _____________

Topography: Level_____ Rolling______ Hilly________ Rugged _________ Rocky_________

Recommended Silviculture: Marking_______________ Species & % cut _______________

Designating: Species & Method____

Knutson-Vandenburg needs:

Planting: Acres________ Species & Age Class________ No. ________ Cost_____________

T. S. I.: Acres________ Kind___________________________________ Cost_____________

*To be filled in only when tally sheet is used in cruising for timber sale.

SURVEY METHODS

Uniform Survey Procedure Approved By
The Lake States Forest Insect Survey Committee - 1956

SPRUCE BUDWORM DETECTION SURVEY FOR THE LAKE STATES REGION

PURPOSE:

The spruce budworm detection survey will provide general information on annual population fluctuations at fixed locations, aid in locating areas of heavy defoliation not previously observed, and obtain quantitative data on budworm abundance at various locations throughout the spruce-fir type.

INSTRUCTIONS:

The survey may be carried out in the following manner:

1. Location of collecting point. --The permanent collecting points should be established in accessible balsam fir stands of several acres in size, and distributed so as to give good coverage of the spruce-fir types in each State. The area in which the collecting point is established should not be subject to cutting for at least 10 years. These points should be established in budworm-susceptible stands; the insect itself may or may not be present. Adequate coverage should be obtained if a minimum of 10 collecting points are established in each of the State's forest districts. Where private, state, and federal holdings occur in the same district the State will be responsible in apportioning the number of points to be established by each. These points can be established at any time to avoid delay at the time of taking records.

2. Selecting trees to be sampled. --Adjacent to the reference point three balsam firs suitable for beating are selected and marked with paint, using 1, 2, and 3 diagonal lines. These same three trees will be sampled annually for budworm larvae and defoliation.

   The selected trees should be: (1) typical of the surrounding stand, (2) just within or at the edge of the stand, (3) as bushy as possible, (4) at least 25 to 30 feet tall, and (5) with live limbs in full sunlight close to the ground. Small trees growing closely with or beneath larger trees may be used, also trees along roads, around fields, campgrounds, or similar openings. At each collecting point a centrally located tree or post should be permanently marked (preferably with paint) with the number of the collecting point and a symbol designating the establishing agency.

3. Taking plot data:

   Numbers 1 through 9 on the attached survey form are self-explanatory.

   Number 10--List each major tree species, starting with the most abundant species; estimate the average height of each species and percent occupied in the overstory.

   Number 11--Estimate length of live crown and average basal width in feet. When one side of live crown is shorter than the other due to shading, determine average from both lengths. The same procedure will be used for basal width.

4. Sampling procedure. --Sampling for the budworm at each collecting point will be made after the larvae have reached the fifth stage in the following manner: (1) place the collecting sheet on ground beneath outer crown of sample tree--at least half of the sheet should project beyond the outer crown of perimeter on the leeward side, (2) using the long pole, brush the lower 10 feet of the live crown directly above the sheet with five heavy downward strokes, (3) count all budworm larvae and pupae falling onto the sheet and record the

number for each tree sampled, (4) estimate defoliation for each tree sampled as none = no defoliation of current growth evident, light = a trace up to 20 percent of the current growth defoliated, medium = 21 to 50 percent current defoliation, and heavy = over 51 percent current defoliation. Divide crown into three levels and estimate defoliation in each part. The average of these three estimates will be the degree of defoliation for the entire tree. When no budworm larvae are recovered from the beating or no defoliation is observed, those items should be recorded on the form.

REPORTING RESULTS:

A new set of data will be recorded each year the collecting point is visited. The same form can be used for these yearly collections.

Each cooperating agency will prepare a map showing the exact location and number of each collection point established; copies of this map will be sent to the State agency designated to receive forest insect reports, and to the Division of Forest Insect Research, Lake States Forest Experiment Station, St. Paul Campus, University of Minnesota, St. Paul 1, Minnesota.

After each collection has been made the completed form should be mailed immediately to the State agency involved. This will include collections made on National Forests. This State agency, in turn, will prepare a yearly summary of these reports for inclusion in the regional report by the Division of Forest Insect Research.

EQUIPMENT:

The survey has been designed so that a minimum of equipment will be needed.

1. One 6' x 8' collecting sheet of unbleached sheeting or similar material.
2. Light pole approximately 10 feet long. (This can be cut on the spot and left for next year's use.)
3. Paint for numbering trees and marking location of collecting point.
4. Supply of Spruce Budworm Detection Survey forms (one copy for each collecting point).

J. L. Bean and H. O. Batzer, Forest Service, U. S. D. A.

SPRUCE BUDWORM DETECTION SURVEY

(1) Collecting Point No.__________ (2) State__________ (3) T R S Forty__________

(4) Collecting Point Location____

____

(5) Reporting Agency____________________ Stand Acreage:__________

(6) Collectors______________________________ (7) Date__________

(8) Staminate Flowers Present (Balsam Fir) YES__________ NO__________

(9) Stand Description

Species	Average Height	Percent of Overstory

(10) Individual Tree Record

Number	D. B. H.	Crown		Spruce Budworm		Percent of Current Defoliation
		Length	Width	Larvae	Pupae	
1						
2						
3						

INSTRUCTIONS

I. Establishment of Collecting Point:

1. Select permanent sampling points within susceptible balsam fir stands. There should be a minimum of 10 points in each state forest district or comparable sampling unit.
2. At each sampling point select THREE balsam firs, preferably dominant or codominant, which are part of the stand but which are fairly well in the open and have low, living branches.
3. Mark the trees with paint with 1, 2, and 3 diagonal lines; locate them accurately by reference to known points and also on a map.

II. Sampling Procedure:

1. Sampling should be done when the larvae are in the fifth stage or instar.
2. Place collecting sheet (6' x 8') on ground on the leeward side and under the crown of each marked tree, with half of the sheet projecting beyond the perimeter of the crown.
3. With a long pole (10' or more) brush the lower 10 feet of the live crown directly above the sheet with 5 heavy downward strokes.

III. Completing Form:

1. Numbers 1 through 8 are self-explanatory.
2. Number 9 - List each major tree species, starting with the most abundant species; estimate the average height and percent occupied in overstory.
3. Number 10 - Estimate crown length and average basal width in feet. Record number of budworm larvae and pupae on sheet. Record defoliation of current growth as NONE when no defoliation is evident; LIGHT - a trace to 20 percent defoliated; MEDIUM - 21 to 50 percent defoliated; and HEAVY - over 50 percent defoliated. Divide crown into three levels and estimate the defoliation in each; the average indicates the degree defoliation for the entire tree.

UNIFORM SURVEY PROCEDURE APPROVED BY THE LAKE STATES FOREST INSECT SURVEY COMMITTEE - 1956

LARCH SAWFLY DAMAGE APPRAISAL SURVEY

PURPOSE:

The larch sawfly, *Pristiphora erichsonii* (Htg.), is found throughout the tamarack type in the Lake States; however, the intensity of infestation varies from place to place. A standard method of appraising the damage is urgently needed so that all agencies can report infestations in a similar manner. The following procedure, in use by the Division of Forest Insect Research, Lake States Forest Experiment Station, is submitted as a means of fulfilling this objective. It can be used once to obtain data on stand condition and severity of defoliation or annually to follow population trends.

Tamarack mortality attributed to sawfly defoliation was observed for the first time in the present outbreak in Minnesota during 1954 and 1955. Landowners may wish to take some means of preventing defoliation and damage because much of the tamarack growing on the better sites will soon be commercially important. Also, it may be the only species that will reach merchantable size on a boggy site. If protection is considered it will be of prime importance to know how much defoliation, over how long a period, is required to cause death of the trees or predispose them to death by other factors. If the majority of the trees will survive, even though growth is reduced, it is doubtful whether protection measures will be necessary. The proposed procedure will give this type of information from year to year.

INSTRUCTIONS:

It will be possible to follow population trends and determine the factors causing, or leading up to, tree decadence by establishing permanent observation points throughout the tamarack areas.

Observation Point Establishment

1. All permanent observation points will be established in easily accessible tamarack stands, pole size or larger, that contain 70 percent or more tamarack and are at least 10 acres in extent. The landowner should be consulted to obtain permission to enter and to request that the stand will not be removed for a period of years. It would be advisable to locate points on public lands away from major highways whenever possible.

2. Each permanent observation point should be specifically located and described on the form attached so that it can be readily found. Each point should be adequately marked, so as to facilitate ease of locating, by a band of paint on a power or telephone pole or on nearby trees.

3. A line of 10 dominant trees, at least 1 chain apart and beginning 2 chains in from the road, will be permanently marked and used for sample trees. Each tree should be marked with a 2-inch band of paint at d. b. h., completely circling the tree; a number, 1 to 10, will be neatly painted above this band. A Valspar-type enamel, tangerine in color, has proved very satisfactory because it shows up well in the woods and has long-lasting qualities. Repainting is necessary when the numbers cannot be determined or in case sample tree is windthrown and must be replaced by a nearby tree of similar size.

4. A square tenth-acre plot (1 chain on a side) will be established in the stand somewhere near the line of sample trees; possibly containing some of them. A line of trees, immediately adjacent to the edge of this plot, will be painted to delineate the plot boundaries; the paint marks should face the center of the plot. The primary purpose of

the plot will be to observe the development of tree decadence.

Field Observations

At each observation point two separate records will be made and marked on the attached form. One is a defoliation record and the second is a bark beetle record. These observations will be made after all feeding by the sawfly has ceased (approximately August 1).

1. Defoliation estimates - A defoliation estimate will be made for each of the 10 marked sample trees. The live crown is broken down into thirds visually, and a separate estimate to the nearest 5 percent is made for each crown level and then an average for the tree is obtained. When averaging, it must be realized that the upper one-third of the crown does not represent one-third of the total foliage. In making the estimates, because defoliation may vary in different quadrants of the crown, it is necessary to walk completely around the tree. Defoliation estimates will be recorded separately for each tree; the plot average will then be based on these 10 trees.

The d. b. h. for each of the 10 marked sample trees will be measured with a diameter tape to the nearest tenth of an inch and recorded on the form.

Total tree height for each sample tree is measured using an Abney level or hypsometer and recorded.

2. One-tenth-acre plot observations - Within the 1/10-acre plot all living trees in a 4-inch d. b. h. class or above will be counted and recorded by species. Only tamarack, spruce, and cedar should be considered.

Of these trees all showing recent bark beetle attack (present year) will be counted and recorded. If bark beetles are present, specimens should be sent in to the State Agency involved, or to the Lake States Forest Experiment Station, for determination.

By following these 1/10-acre plots over a period of years, some idea of tree decadence will be obtained. The recording of spruce and cedar as well as the tamarack should make possible the detection of tree decadence resulting from other factors besides the sawfly. An example would be excessive high water over a relatively long period. This should be reflected in all three tree species even though it may affect each in a different degree.

All field data should first be sent to the proper State agency; after being recorded the material can then be forwarded to the Lake States Forest Experiment Station for coordination. (L. C. Beckwith, Forest Service, U. S. D. A.).

LARCH SAWFLY DAMAGE APPRAISAL SURVEY

(1) Collecting point No._________ (2) Approx. acreage sampled________ (3) Date_________

(4) Location: T_________ R_________ S._________ (5) Landowner____________________

(6) Reporting agency__________________________ (7) Observers____________________

(8) Stand condition:

Density:	Poor	Medium	Good
Site :	Dry	Hummocky	Wet

(9) Individual tree record

Tree No.	DBH	Ht.	Defoliation %
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average			

(10) 1/10-acre plot

		Tamarack	Spruce	Cedar
(a) No. living trees above 4" DBH class				
(b) No. trees containing bark beetles				
(c) No. trees dead but not harboring bark beetles				

(11) Larch casebearer: None Light Medium Heavy

(12) Remarks:____

Instructions for Reporting Larch Sawfly Conditions

(1) For Reporting Agency only.
(2) - (7) - Self-explanatory.
(8) Underline one that best pertains to the stand.
Density: Forest Service Classification - Poor (100-224 trees/acre), Medium (225-324 trees/acre), Good (325+ trees/acre).
Site : Dry and wet are self-explanatory; hummocky refers to a stand that has very irregular ground surface, the high areas are generally dry while the depressions are generally wet.
(9) Tree record: Tree No., DBH (in tenths of an inch), Ht. (in feet), Defoliation percent (ocular estimate to the nearest 5 percent)
(10) 1/10-acre plot (1 ch. square).
(11) Larch casebearer - Record spring defoliation.
(12) Any additional information concerning the stand condition.
(RETURN TO STATE AGENCY IN CHARGE OF SURVEY.)

LARCH SAWFLY
(as used in the Lake States)

Beginning in 1949, reconnaissance surveys of forested areas subject to larch sawfly (Pristiphora erichsonii) attack have been conducted annually to assess not only the magnitude of the infestation, but the duration and intensity of attack preceding tree mortality. Depending on seasonal conditions, surveys are conducted during late July or early August. In these surveys combinations of aerial and ground methods have been used in Minnesota, while ground methods alone have been used in Wisconsin and Michigan. Because of the inaccessibility of most tamarack stands to ground travel, aerial methods have a peculiar advantage. With refinements in technique they seem to offer the greatest promise for compiling worthwhile annual records reflecting larch sawfly abundance.

Aerial Survey

Survey Plan: Aerial reconnaissance surveys in 1949 and 1950 consisted of planned random cruises of tamarack concentrations, especially those in national forest areas and in counties from which the sawfly had been reported. Experience during these earlier surveys indicated the need for a more comprehensive and systematic approach in using aerial methods to delimit zones of defoliation over large areas from year to year, and in 1951 this sort of approach was taken. The system employed was an adaptation of the technique developed for spruce budworm surveys in the Northeast to meet the need for more accurate means of mapping defoliator damage than the sketch mapping method commonly used. Those familiar with timber cruising methods can best visualize it in comparison to a line strip cruise made on the ground. Evenly spaced flights are made over the forest at a constant altitude above the ground. Along the flight lines each observer examines a strip of timber and records his ocular appraisal of conditions viewed according to predetermined categories. This information is continuously transmitted via electrical keyboard to pens registering on the moving chart of an operation recorder. The observations registered on the chart of this instrument are then transcribed onto maps using any system which will permit connecting points of similar observations by isomorphic lines. A survey of this type has been designated an operation recorder aerial survey.

Equipment: A 5-passenger Cessna 195 high-wing monoplane was made available for the 1951 survey late in the summer by the U. S. Bureau of Entomology and Plant Quarantine's Beltsville, Md., forest insect laboratory. This plane was specially equipped for low altitude flying usually necessary in defoliator surveys. It contained, in addition to an Esterline-Angus operation recorder, and full length plexiglass doors for maximum visibility, a radio-altimeter and gyro compass to facilitate maintaining proper altitude and direction.

Procedure: In this survey the entire forested area of Minnesota north of Duluth (approximately 15 million acres) was covered by a system of parallel flight strips at 12-mile intervals, extending in an east-west direction. These flight strips were laid out in advance of aerial operations on large scale maps (1 inch - 2 miles), showing prominent topographic and cultural features, as well as the land subdivisions. Such maps, compiled by the various states in cooperation with the U. S. Bureau of Public Roads, are available in most states. The individual map sheets were assembled into a single composite map of the entire areas to be covered. The course of each flight was plotted on the composite, and at convenient intervals readily recognizable points of reference, such as intersections with lakes, rivers, highways, etc., were designated by number along each course. These points of reference served as check points in maintaining the proper alignment of flights, and were identified by the pilot, who recorded the appropriate number in Morse code on the operation recorder chart as each was crossed. For convenient use in the airplane, the composite map was cut into strips, each containing about 3 flight lines, and folded.

The survey flights were made at an altitude of 500 feet above the ground and at an indicated airspeed of 120 miles per hour. Stand conditions were appraised by two observers, each viewing a separate strip approximately 5 chains wide on opposite sides of the plane. Conditions observed were classified according to five categories, and, through separate switchboards for each observer, were recorded on the operation recorder chart. The categories used were: (1) non-tamarack type; (2) water; (3) non-defolitated tamarack, i. e., no observable defoliation from 500 feet, although very light defoliation may have been present; (4) partially defoliated tamarack, i.e., defoliation easily observable, but varying amounts of green foliage present; (5) completely defoliated tamarack, i.e., all or almost all of the foliage destroyed. In this manner two separate, independent, and continuous strip samples were made the entire length of the respective flight lines. When the daily flying was done, proportional dividers were used to transfer the recorder chart data directly to the strip map. The plane speed between each check point was assumed to be constant, so that once the ratio between each pair of check points on the map and on the recorder chart was determined it was a simple matter to plot the portions of the strip in the different categories. A color code system was used to differentiate tamarack condition classes on each strip. For example, if red was the color which identified complete defoliation, a band of red would be inscribed at the exact places and for as long as was indicated by either or both observers. Thus, when tamarack condition classes on each strip were designated by the appropriate color, the picture for any given locality was readily apparent.

When the strip maps were reassembled into the original composite of the area covered, it was evident that the overall picture of damage was obscured by excessive detail at the 1-inch to 2-mile scale. To prepare the final map, it was necessary to group the strip data by townships. This was done by measuring the strip length in each township, and computing the percent of the sample in each tamarack condition class. The township was then given designation corresponding to the condition class in which 50 percent or more of the tamarack fell. For example, if the average length of strip for all tamarack condition classes in a given township was 4 miles, and 2 miles (50 percent) was classed as completely defoliated, the entire township was arbitrarily designated as being completely defoliated. On the basis of the values thus obtained, generalized zones of damage reflecting the different levels of larch sawfly infestation in tamarack stands were established.

Ground Survey

Plots are established throughout the infested area and adjacent uninfested tamarack type. Paint-marked stopping points along roads facilitate the operation, and attempts are made to paint-blaze sufficient trees, poles or boulders to make the spot easily identified from a moving vehicle. Paint-blazes also lead into the plot proper. Data are compiled from the percent defoliation (nearest 5 percent) of ten well spaced (2 chains if possible) paint-numbered tamarack trees.

Ten minute cocoon collections are also made under three trees, totaling 1/2 man hour of work. In order to observe possible evidence of stand decadence, 1/12-acre (1 chain by 1 chain) plots are also maintained at each defoliation plot. The bounds of this plot are amply painted in, and a hundred percent survey of each 4" or larger tamarack is made for eastern larch beetle (Dendroctonus simplex) which often attacks weakened trees. Data are kept on the total number of tamarack trees and those infested. (Division of Forest Insect Research).

GYPSY MOTH

In determining the specific location, size and extent of gypsy moth (Porthetria dispar) infestations trapping and scouting surveys are annually conducted. Trapping surveys involve the use of sex attractant which is obtained by clipping the last two segments of the abdomen of adult virgin female gypsy moths into benzol to extract the attractant from the sex glands. At the 15-tip strength, traps attract male moths for distances up to 1/2 mile. The traps are placed in the field late in June or early in July and are visited approximately once each week during the entire flight season to freshen the tanglefoot placed on wax paper within the metal cylinder by combing and to remove moths that may have entered the trap and become lodged on the tanglefoot. Where the gridiron method is employed parallel lines are run through the forested areas by the use of a compass and the traps are normally placed at 7/8 mile intervals. In trapping along roadsides traps are placed one mile apart. This method of surveying extensive areas commenced in a largescale way in the summer of 1942 when a total of 7,282 traps were used in surveying 2,950,000 acres. Approximately twice this acreage was surveyed the following year and in the summer of 1950, 19,608 traps were used in surveying more than 7,193,600 acres.

Plans for scouting are principally based on the results of the trapping program and in general, surveys of this nature are confined to an examination of territory within 1/2 mile of the attracting trap. However, some scouting is annually conducted in areas where traps are not used because infestation is known to be present. Such surveys are conducted so as to delimit the areas infested, determine the intensity of infestation, and hazard of spread of the gypsy moth by wind or common carriers.

Data obtained from the scouting surveys is used in setting up the spraying program on a priority basis to insure early treatment of those areas where the hazard of spread is greatest. (J. M. Corliss).

Uniform Survey Procedure Approved By
The Lake States Forest Insect Survey Committee - 1958

WHITE-PINE WEEVIL APPRAISAL SURVEY

PURPOSE:

The white-pine weevil has been a serious pest of pines and spruces in the Lake States for many years. Infestations can be severe in white, jack, Scotch, and red pines and in Norway spruce. Other species sometimes seriously damaged are Austrian pine and white spruce. Direct control measures to prevent attack have met with some degree of success. An appraisal survey is required to enable the forester and the entomologist to determine the degree of infestation to be used as a guide in making control recommendations.

INSTRUCTIONS:

Time of Survey

The time when weevil attack first becomes evident will depend on the locality, weather conditions, and tree species. For the Lake States in general this will be about mid-June. The effects of weeviling will be readily visible for the remainder of the season.

Method of Survey

This survey involves determination of the percentage of attack presently occurring in a plantation. Data obtained will be classified in categories representing light, medium, heavy, or no weeviling. The first sample is taken at least 1 chain from the edge of the planting. At this point the observer tallies 10 trees along the row. To establish the second sample 2 chains are paced from the last tree examined. Subsequent samples are taken in the same manner until the end of the row is reached. Additional sample lines are run through the planting at 5-chain intervals. When the plantation is not established in rows - some types of underplanting for example - and does not lend itself to line sampling, cluster samples of 10 trees should be taken along a compass line. The intervals should be the same as for regularly spaced rows. A minimum of one sample for each acre of plantation, having less than 1,000 trees per acre, is required for accurate results. Two samples are required for plantations having more than 1,000 trees per acre. The observer may obtain this average number of trees per acre by establishing, at random, three 1/50-acre circular plots (16.6 feet in radius) in each plantation.

Tallying Data Sheet

Each sample consists of 10 trees approximately 2 chains apart. Only the currently weeviled trees should be tallied.

Column: 1. Weeviled trees - current year's weeviling.

2. Non-weeviled trees - can be previously weeviled but not in the current year.

3. Cumulative total of weeviled trees - this column represents the total for the previous plots.

Example:

Plot number	Number weeviled	Cumulative total weeviled	Non-weeviled
1	2	2	8
2	3	5	7
3	1	6	9

SUMMARY OF DATA

Categories for the seriousness of damage are based on percentage of weeviling arbitrarily established for this survey at the following levels.

Heavy - 25 percent or more of the sampled trees weeviled.

Medium - 10 to 25 percent of the sampled trees weeviled.

Light - Less than 10 percent of the sampled trees weeviled.

Determination of the needs for control will vary with values placed on individual plantations by the owner. (S. E. Banish, Wis. Conservation Dept.).

WHITE-PINE WEEVIL APPRAISAL SURVEY

Description: T._____ R._____ S._____ Forty:__________ Date:__________

Host:__________ Acreage:__________ Age:_____ Spacing__________

Average Height of Trees:__________ Average Number of Trees Per Acre:__________

Plot Number	Number of Trees			Plot Number	Number of Trees		
	Weeviled	Cumulative Total	Non-Weeviled		Weeviled	Cumulative Total	Non-Weeviled
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			
TOTAL				TOTAL			

Classification of Infestations of Livestock Pests

The following methods of determining insect infestations are used primarily for research investigations and the techniques may need adjusting to meet field survey conditions.

CATTLE GRUBS - Examine infested portion of animal's back. When average number of cysts (grubs) per animal is 1-10, light; 11-20, medium; over 20, heavy. NOTE: Yearlings and bulls usually more heavily infested than older or younger animals.

HORN FLIES - Count or estimate number of flies on ten animals in herd. Average number of flies per animal 1-25, light; 26-100, medium; over 100, heavy. NOTE: Flies will be more difficult to count in the cool and extreme hot hours of the day. Bulls and dark-colored animals will usually carry heavier infestations than other animals in the herd.

HORSE FLIES and DEER FLIES - Count number of flies visiting animal for a 15 minute period. Average count of 1-5 per animal, light; 6-10, medium; 11 or more, heavy.

STABLE FLIES - Usually the heaviest feeding of flies will be observed from 9:00 to 10:00 A.M. and 3:00 to 5:00 P.M. Count number of flies feeding on animal. Average count per animal of 1-5, light; 6-10, medium; 11 or more, heavy.

CATTLE LICE - A. Sucking species - Observe and examine animals for greasy appearance on dewlap and poll or neck and the presence of lice on muzzle, around eyes and in brush of tail. Occasional louse observed, light; 5-10 lice per examination area, medium; over 11, heavy. B. Chewing species - Observe and examine animals for loss of hair, rubbing, etc. Part hair for examination. Occasional louse observed, light; 5-10 lice per examination, medium; over 11, heavy. NOTE: Abundance of lice in herd largely influenced by seasonal changes and individual susceptibility of host.

GOAT LICE - Part hair in 5 places. One on neck, one on each side and two on belly. Estimate number of lice per hair part. Average lice per goat 1-10, light; 11-25, medium; 26 or more, heavy.

HOG LICE - Examine behind ears and fore legs, on belly and between hind legs. Count lice observed. Average lice per animal: light - 1-10; 11-20, medium; and over 20, heavy.

POULTRY LICE - Examine 5 fowls, part feathers in 5 places under each wing, vent, back and breast or neck. Count lice at each part. Average number of lice per fowl 1-5, light; 6-10, medium; 11 or more, heavy.

FOWL TICK - Examine both fowls and premises. A. Larvae on fowls - Make counts under each wing, on inside of each leg and near vent. Average number of larvae per bird 1-5, light; 6-10, medium; over 11, heavy. B. Adults on premises - Examine roosts, nests, etc. Adults hard to find, light; adults readily noticeable, medium; adults plentiful, heavy.

ROOST MITES - Examine roosts and nests for presence of mites. Occasional mite observed, light; readily observed, medium; numerous, heavy.

FLEAS - A. Sticktight - Examine comb and wattle of 5 birds. Count number of attached fleas. Average count per bird 1-5, light; 6-10, medium; 11 or more, heavy. B. Dog and cat fleas - Walk around infested premises and estimate number of fleas on pants leg in one minute. 1-5, light; 6-10, medium; 11 or more, heavy.

LONE STAR TICKS and WINTER TICKS - Examine foot square area in 5 places on animal. One on each side of neck, one on each side and escuthcheon. Estimate number of ticks present in each area. Average tick count per animal 1-10, light; 11-25, medium; more than 26, heavy.

GULF COAST TICKS - Examine outer surface of ears. Count number of ticks on ear. Average number of ticks per ear 1-5, light; 6-10, medium; 11 or more, heavy.

EAR TICKS - Examine folds on inner surface of ear. Count number of ticks without removal, if possible. Average number of ticks per ear 1-10, light; 11-20, medium; over 20, heavy.

FLEECEWORMS - Examine areas of soiled fleece. More prevalent during warm, humid weather conditions. One case in 100 animals, light; 2-3 cases in 100 animals, medium; 4 or more cases in 100 animals, heavy.

SCREW-WORMS - Examine animals or obtain information from ranchers, farmers, veterinarians and insecticide dealers. Less than one case per 100 animals, light; 1-2 cases per 100 animals, medium; more than 2 cases per 100 animals, heavy.

SHEEP KEDS - Count pupae and adults by parting wool - 25 parts, mostly on body of animal. Average count of 1-5, light; 6-10, medium; more than 11, heavy.

FOWL MITES - Examine for presence of mites in feathers. Part feathers in 5 places. Estimate number of mites under each wing, on each side and about vent. Average number of mites per fowl 1-10, light; 11-25, medium; 26 or more, heavy.
(C. L. Smith and W. S. McGregor).

Technique for Counting Cattle Lice

1. One square inch samples are taken from the area of infestation either with a straight razor, knife or simply by scraping with the thumb-nail. These are preserved either in AGA*or 70 percent alcohol in 2-ounce screw top specimen jars. Samples are labeled as to date, place taken, and the species.

2. The first step is to remove the entire sample from the preserving fluid and dissolve all the hair by boiling in 10 percent KOH.

3. When the hair is completely dissolved the sample is transferred to a centrifuge tube and centrifuged until all the lice are brought down. Most of the KOH is then removed by a rubber bulb and pipette. The sample is then washed with water, centrifuged and the water removed to take out as much of the KOH as possible.

4. Water is added to the centrifuge tube and the sample agitated by shaking until all the specimens are suspended. The sample is then poured over a filter paper in a Buchner funnel set over a filter flask. Attachment of the filter flask to a water aspirator pump speeds filtering. Removal of the KOH is essential if successful filtering is obtained.

5. The filter paper on which the lice are caught is divided into 8 segments for easier counting.

6. Sex determinations may be made with the aid of a binocular microscope and males and females removed with a needle to separate Syracuse watch glasses containing AGA or alcohol. Nymphs and eggs are counted directly on the filter paper. A tally counter aids in taking the count.

7. Petri dishes containing filter paper moistened in AGA were found to be excellent for holding over lice collected by the Buchner funnel from day to day or over a week-end.
(J. L. Lancaster, Jr.)

*Alcohol, glycerin, glacial acetic acid.

Technique for Calculating the Number of Mosquito Larvae Per Acre

Sheet iron cylinders 10 inches long covering 144 square inches (13.5" diameter) were constructed. One half inch mesh hardware cloth was soldered over one end. In making counts the end covered with hardware cloth was at the bottom of the cylinder as it was dropped at random in the water. The purpose of the hardware cloth was to prevent and excessive amount of vegetation extending upward into the cylinder. Then using a six-inch sieve covered with 60 mesh screen, the enclosed water is agitated and the larvae are dipped from the cylinder and counted. The count was considered complete when five successive dippings produced no larvae. Ten such counts were made in the area and the average of these numbers was multiplied by the number of square feet per acre. (F. E. Whitehead).

A CORN EARWORM SURVEY TECHNIQUE

For several years entomologists in Indiana have been attempting to obtain an estimate of the fall infestation and damage of the corn earworm to dent corn. This has been done by making an earworm survey along with the annual corn borer survey.

Methods: Considering the amount of time and budget that could be allocated to a survey, it was decided that a maximum of 200 fields could be sampled in the State. The sampling sites were selected as follows. The State of Indiana was divided into 11 regions depending upon location and soil types. Each region consisted of seven to ten counties. The 200 sampling sites were then divided among the regions proportionately according to the corn acreage. In this way, the northwest central region, consisting of seven counties with the highest corn acreage, was apportioned 25 sampling sites. The southeast region also consisting of seven counties had only seven sampling sites due to its much lower corn acreage.

Sampling sites were predetermined in each region and marked on a map so that the entomologists making the survey obtained the sample by driving directly to the location and sampling the corn field nearest to the site. In predetermining the sampling sites an attempt was made to proportion the fields accordingly in areas of muck, loam, and sandy soil types.

Fields were sampled by walking 50 paces into the field and then examining the ears of 25 consecutive plants. Any ear that had been damaged by the earworm whether the insect was still present or not was considered infested. The first two infested ears were removed and the number of destroyed kernels on each ear counted. Allowances were made for small kernels near the terminal end of the ear that might not be expected to develop under normal conditions. The data from these two ears were averaged and a percentage loss calculated based upon the average total number of kernels per ear from two representative uninfested ears selected from the field. There was very little variation in the number of kernels per ear in a variety in a field. Regional data were determined by averaging all fields in the district. (M. C. Wilson, G. E. Gould, R. T. Everly, and D. L. Schuder)

United States Department of Agriculture
Agricultural Research Service

A SAMPLING FORK FOR ESTIMATING POPULATIONS OF SMALL ARTHROPODS[1/]

By Charles F. Henderson, ENT[2/]

When studies of the biology, ecology, and control of the brown wheat mite (Petrobia latens (Mull.)) were planned, it was first necessary to develop a method of estimating mite populations on various small grains. The first method tried was to dislodge the mites by brushing the host plant back and forth with the hand, and to count those that fell on a white card held beneath the foliage. These mites readily fall to the ground when the plant upon which they are feeding is disturbed. However, this procedure was too slow where large numbers of small-unit samples had to be taken quickly under comparable conditions of temperature, light, and time of day. Population estimates in plots sampled early in the day were not comparable with those taken later. Furthermore, a method was desired in which the samples could be taken to the laboratory and the mites counted under more favorable conditions. The apparatus and technique developed for these studies are described herein.

Description of Fork

In the fall or winter when the plants are small, the most satisfactory population estimates may be made by counting the mites on the foliage of 1-foot sections of planted row, with a head binocular (fig. 1). In the spring and summer after the plants had begun their upright growth, the mites were caused to drop from foliage to adhesive-covered glass slides held in a galvanized-iron sampling fork (fig. 2)., similar to one described by Lawson (1). This fork consists of four tines attached to a tubular steel handle that extends from the base at an angle of about 15 degrees. Around the edge of each tine is a retaining rim. The points of the tines are beveled on the bottom to prevent them from digging into the ground when the fork is pushed along the soil surface. The slides are of single-strength window glass, and just large enough to slip into the rectangular chamber of the tine.

For convenience in handling, four slides are placed in an aluminum clip which has the ends turned back over the slides so that the glass surfaces will not touch when several clips are stacked (fig. 3). Two upturned stops on the back margin of the clip prevent the slides from falling out. While held in the clip, the upper surfaces of the four slides are coated by brushing with a hot mixture of mineral oil and vaseline. The proportion of the two ingredients depends upon field temperatures. The mixture should be fluid enough to spread uniformly in a thin film over the slide without showing brush marks, but firm enough not to flow under high temperatures. Brush marks greatly hinder the counting, as only those mites directly above white areas showing through the glass slides are counted, and the uneven refraction of light through irregular adhesive surfaces obscures the outline of these areas. Three parts of mineral oil to one of vaseline is satisfactory; the proportion of vaseline is increased with higher temperatures and decreased with lower ones. The mixture may be applied cold, but it is more difficult to avoid leaving brush marks when applying a thin film. After the slides have been coated, they are stacked in one side of a metal slide box (fig. 4). This box has two compartments--one for carrying the clean, coated slides to the field and the other for holding the slides after the mites have been collected. Three of these slide boxes are placed in a metal case for carrying to the field (fig. 5). A large number of the slides may be coated and held indefinitely in these carrying cases for future sampling. In the field to be sampled a slide box is removed from the carrying case and taken to the sampling site. A clip of slides is taken from the box and rested on the flat surface of the fork. The slides are then removed individually from the clip and inserted in the tines of the fork with the adhesive surface on top, being held in position by the retaining rim (fig. 6). The sampling fork is then ready for use.

1/ This has been superceded by ARS-33-18; March 1956
2/ In cooperation with the Kansas and Oklahoma Agricultural Experiment Stations. Contribution No. 655, Department of Entomology, Kansas Agricultural Experiment Station.

Using the Fork

The fork containing the coated slides is inserted through the base of the plant at ground level (fig. 7), and the foliage is disturbed by brushing with the hand so that the mites will drop to the ground; those that fall on the slides are held by the adhesive. The fork is then withdrawn and the slides are replaced in the clip. The bottom or outside top margin of the clip is labeled with a lead pencil as to sampling site, date, host, or other desired data. The clip of slides is then returned to the holding box, and when all the collections have been made the box is placed in the carrying case and brought back to the laboratory for counting. The samples may be held in good condition for many days in the refrigerator.

Counting the Mites

For counting the specimens a thin transparent celluloid card is inserted between the glass slides and the metal clip. This counting card (fig. 8) has four white areas 1/4 or 1/8-inch wide and 4 1/4 inches long, so arranged that they will coincide with the approximate centers of the four slides when the card is shoved tightly against the retaining stops. The white areas may be made with plastic paint or plastic tape. Counting is done with reflected light from an ordinary microscope lamp. When a card containing 1/4-inch strips is used, each slide represents a sample area of 1.06 square inches, and each fork 4.25 square inches (approximately 1 inch of planted row). When a 1/8-inch strip is used, one-half these areas are represented. No statistical differences were observed between counts made with the two areas. Other types of counting patterns may be used, such as four 1/4-by 1-inch areas placed one above the other in the center or run diagonally across the card. The differences between such patterns did not exceed 4 percent. If the number of mites present over the counting area is not sufficient for an adequate count, the entire slide may be examined under lower power. Furthermore, where low populations occur or slide-carrying space is limited, as on an extended survey, a composite sample may be taken on a single set of four slides, and so labeled. After the counts have been completed, the slides are placed in a cylindrical wire screen basket and submerged in a solvent (fig. 9) where they are agitated a few times and then allowed to soak to dissolve the mineral oil and vaseline. The clean slides may then be wiped with a rag or placed in hot water and spread out on a rack to dry. If cleaner slides are desired, they may be agitated in hot, soapy water after being removed from the solvent, and then rinsed in hot water. The metal clips are cleaned by wiping with a rag moistened with solvent, or soaking in the solvent and then wiping.

Other Uses of the Sampling Fork

The sampling fork was found to be very satisfactory for estimating populations of the spotted alfalfa aphid and various species of thrips and other insects found in alfalfa fields. However, the optimum proportion of mineral oil and vaseline varies with the insects being collected. For example, a 5 to 1 mixture retained practically all the aphids, whereas a few were able to excape when 3 parts of mineral oil to 1 part of vaseline was used. When several species are present, the proportion should be the one that will catch those insects most likely to escape. By this procedure the fork should be practicable for sampling any small arthropod attacking small grains that has a tendency to fall when the plant is disturbed. The color of the counting area on the celluloid card should vary with the color of the insect. For example, for the spotted alfalfa aphid, which is pale greenish yellow, a dark background should be used. For the brown wheat mite and other dark species a white background is the most satisfactory.

Literature Cited

(1) Lawson, F. R., D. E. Fox, and W. C. Cook
1941. Three new devices for measuring insect populations. U. S. Bur. Ent. and Plant Quar. E-183, 6 pp.

Figure 1.--Counting brown wheat mites on small wheat plants in 1-foot sections of planted row with head binocular.

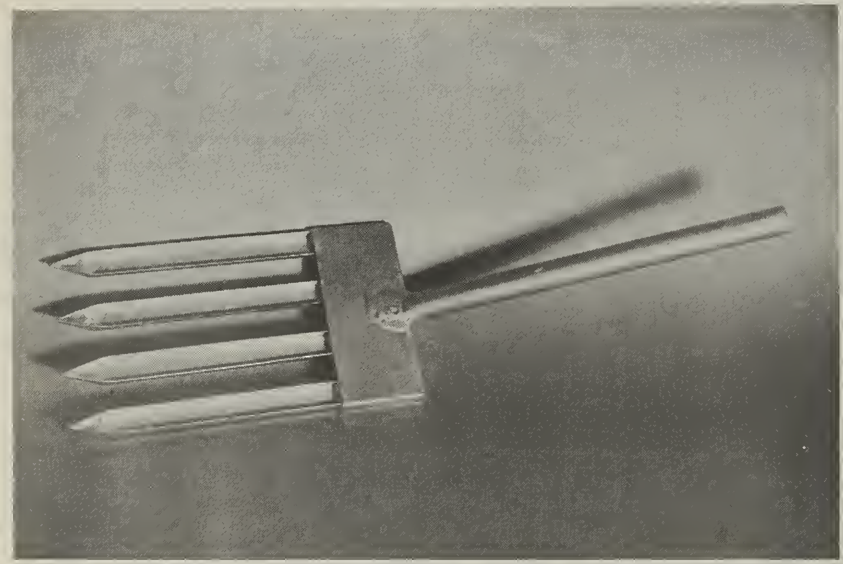


Figure 2.--Sampling fork for collecting brown wheat mites from foliage of small grains for counting.

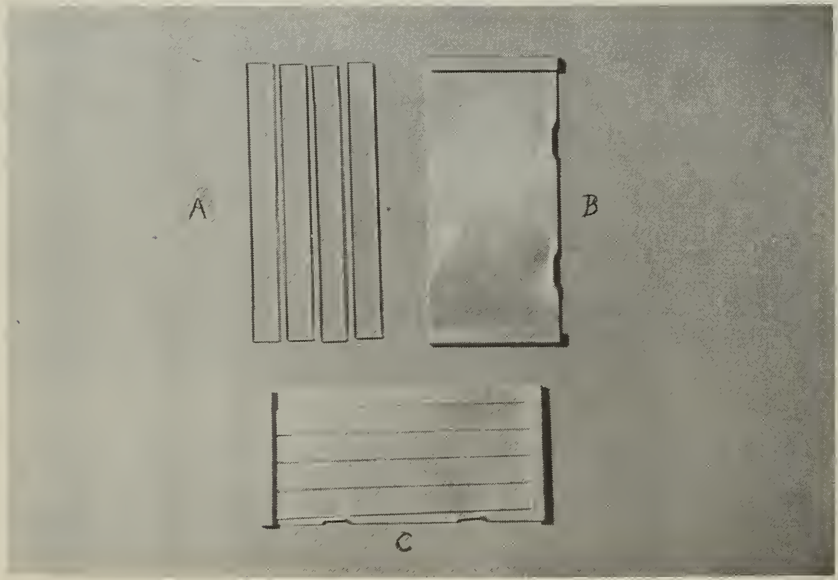


Figure 3.--A, glass slides; B, aluminum clip; C, glass slides in clip ready for application of adhesive.

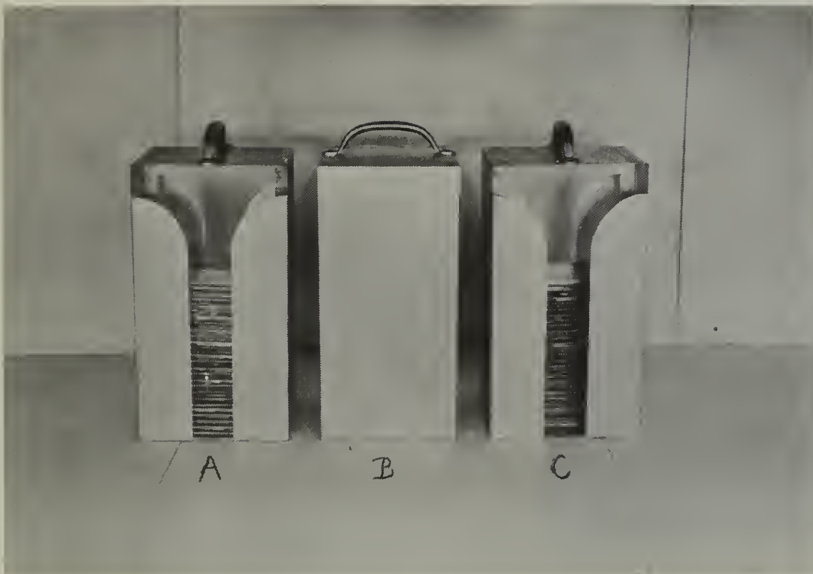


Figure 4.--Slide box for carrying clips of coated slides to sampling site; A, front view showing empty slides stacked in front compartment; B, side view; C, front view showing slides in rear compartment after collections have been taken.

Figure 5.--Carrying case for holding three slide boxes.

Figure 6.--Inserting coated slides in tines of sampling fork before taking collection.

Figure 7.--Sampling clump of grass for populations of brown wheat mite.

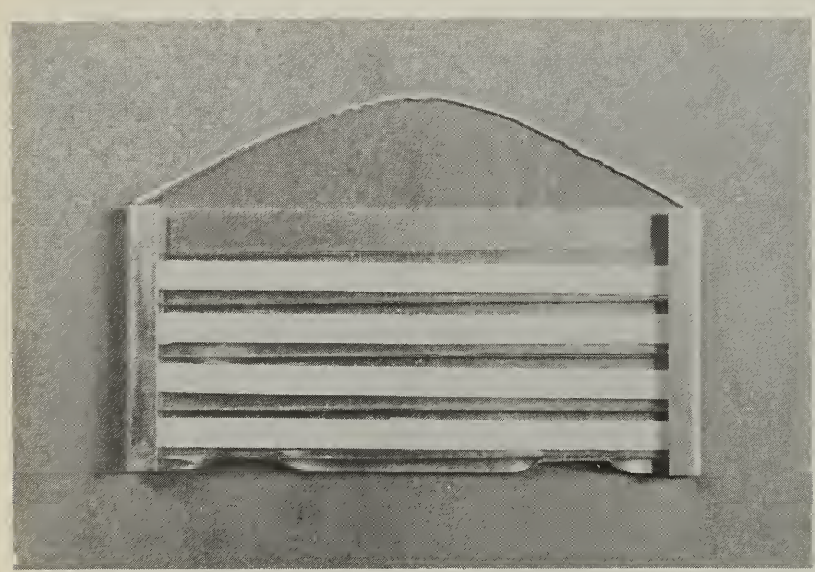


Figure 8.--Celluloid counting card inserted between glass slides and metal clip. White counting areas are 1/4 inch wide.

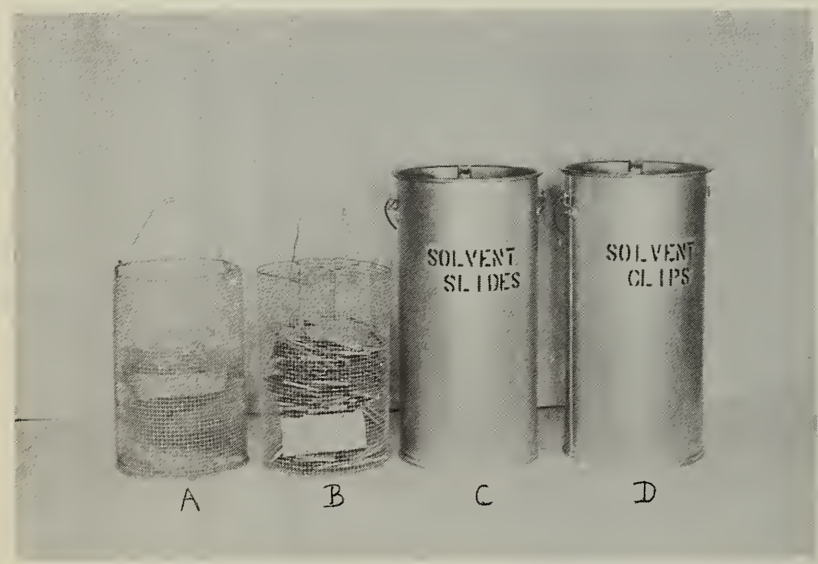


Figure 9.--Apparatus used in cleaning slides: A, Wire basket of clips ready for soaking in solvent; B, basket of clips; C, cream can containing solvent for cleaning slides; D, solvent for cleaning clips.

PICTORIAL KEYS

NOTES AND ILLUSTRATIONS FOR FIELD SEPARATION OF FIRE ANTS

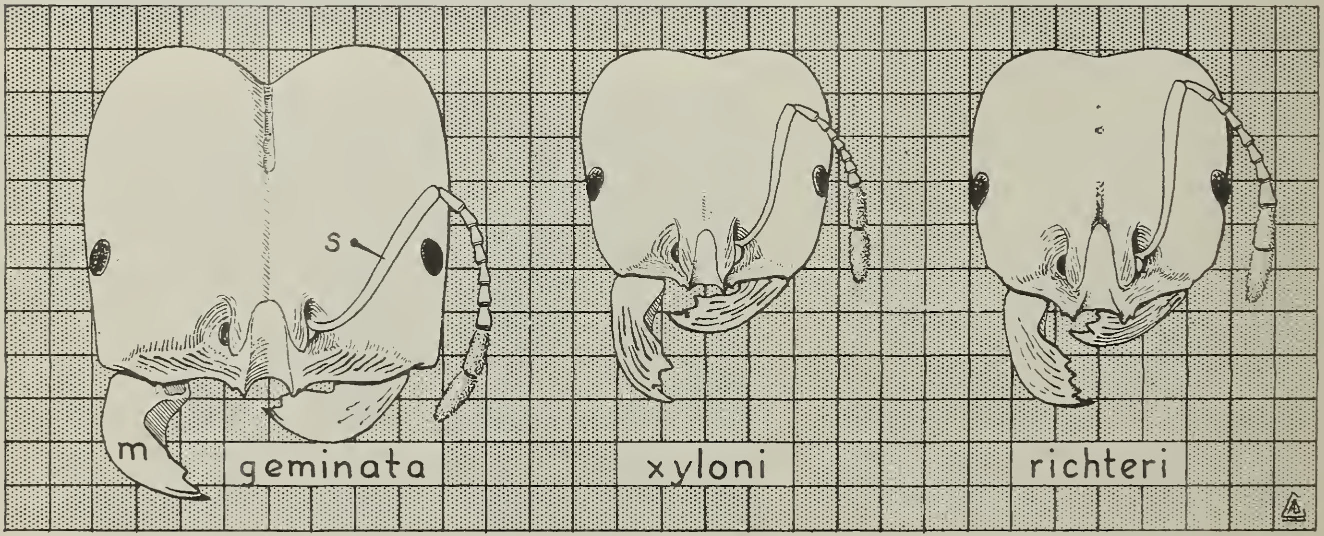
The following illustrations have been prepared to assist field personnel in making gross examinations of the very largest workers, the ones that usually do not have wings, of Solenopsis geminata (F.) (tropical fire ant); Solenopsis xyloni McCook (southern fire ant) and Solenopsis saevissima richteri Forel (imported fire ant).

All three of these forms build mounds, but it is impossible to determine the species from the mound alone. These mounds are most commonly found in open places, such as roadsides, fencerows, railroad right-of-ways, open woods, pastures, margins of cultivated fields, edges of streams, around ponds and high areas in moist places.

S. geminata (F.) -- The largest workers of this species have unusually large heads which are out of proportion to the rest of the body and can be readily seen with the naked eye. Because usually less than one percent of the colony are major workers, a very careful examination of the mound is necessary to find them. The illustration is an outline drawing; the mandibles are usually darker than the rest of the body, incurved and usually without pronounced teeth.

S. xyloni McCook and S. saevissima richteri Forel -- The separation of xyloni and richteri is very difficult and positive identification should not be made in the field.

Note the illustrations: Xyloni has a noticeably shorter scape. (The scape or first segment is that portion of the antenna which is unusually long and attached to the head.) The scape of richteri is noticeably longer. The mandible of the largest worker of xyloni is usually three-toothed. (Sometimes an irregular projection appears above these three teeth.) In richteri the mandible of the largest worker is rather distinctly four-toothed. (ENT and PPC, ARS) CEIR 7 (48) 11-29-57



Structural Characters for Recognition of Cotton Stem Moth (Platyedra vilella (Zell.))

The following combination of characters will separate the larvae and pupae of Platyedra vilella (Zell.) from those of other species associated with hollyhock and other malvaceous plants. Treatment of the adult has been omitted because characters for ready recognition in the field are not known.

LARVA:

Head - with anterior puncture A_a between anterior setae A_1 and A_2, near A_2.

Prothorax (TI) - with 3 setae on the prespiracular shield.

Abdominal proleg-bearing segments (A_{3-6}) - with seta iv approximate to seta v, both on same pinaculum.

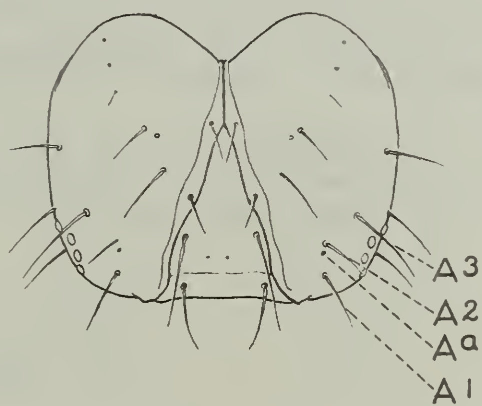
Eighth abdominal segment (A_8) - with group vii composed of 2 setae.

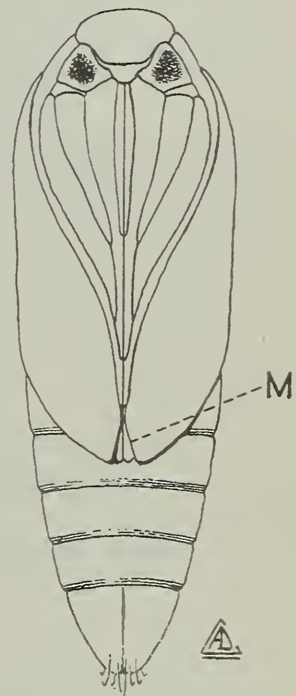
Ninth abdominal segment (A_9) - with seta iii more slender than setae i or ii; seta vi absent.

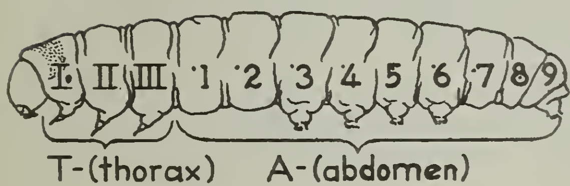
Crochets (C) - on abdominal prolegs (A_{3-6}) uniordinal in length, arranged in a penellipse.

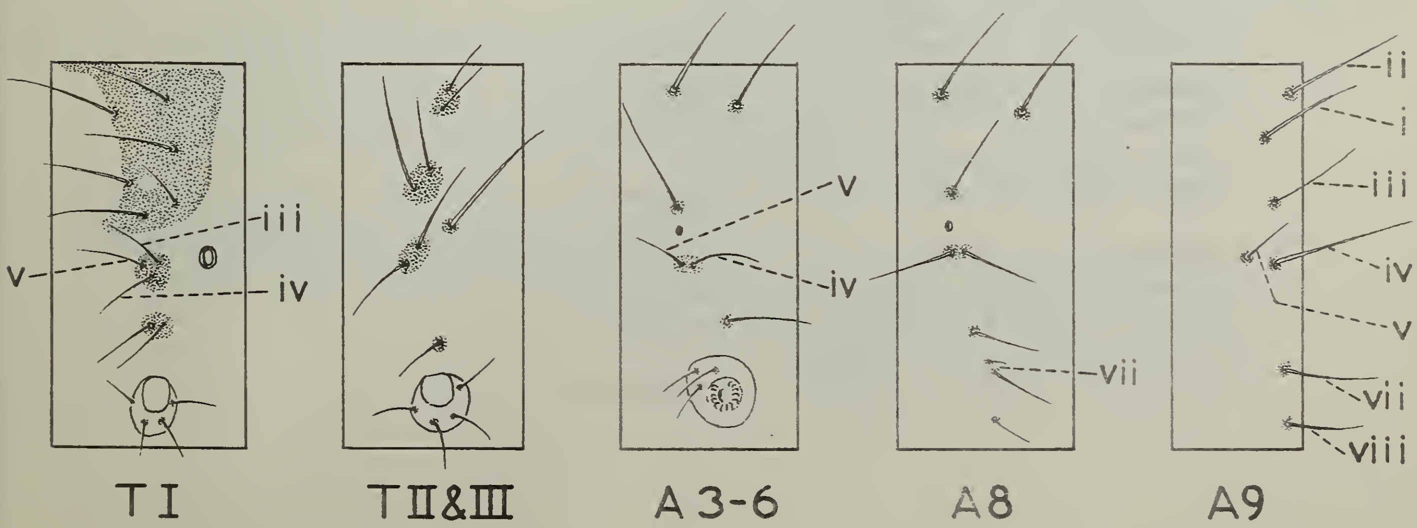
PUPA: clothed with short, fine, pubescent-like hairs; anterior margins of fore wings (M) contiguous at a point near end of labial palpi, from which they are divergent (never parallel) to apices of wings. Length 8 to 10 mm.

H. W. Capps









ILLUSTRATED KEY TO SPECIES OF TROGODERMA AND TO RELATED GENERA OF DERMESTIDAE COMMONLY ENCOUNTERED IN STORED GRAIN IN CALIFORNIA

The keys which follow are partly original work and partly from three other sources: 1. Hinton, 1945; 2. Beal, 1954; 3. Howe and Burges, 1955. The adult characters distinguishing the species of Trogoderma are largely the work of Okumura. The larval key is by Blanc and the characters used are from Hinton and Beal except for particularly important characters defining granarium, which are from Howe and Burges.

References cited are:

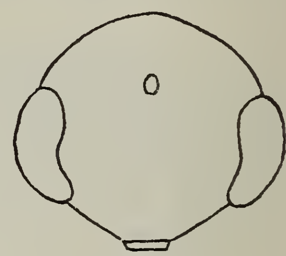
1. Hinton, H.E. Beetles Associated with Stored Products British Museum, 1945.
2. Beal, R. S. Jr., Biology and Taxonomy of the Nearctic Species of Trogoderma University of California Pub. in Ent., 10(2): 35-102, 1954.
3. Howe, R. W., and Burges, H.D., Trogoderma afrum Pr., a synonym of T. granarium and a comparison with T. versicolor. (In press).

To work the keys it is necessary to make microscopic dissections of adults and slide mounts of the larvae. Some of the drawings are diagrammatic and complete in detail only to the extent necessary.

A. ADULTS

1. Head with a median ocellus (A); species usually less than 5.5 mm. long........2

   Head without an ocellus; species usually 5.5-12 mm. long......DERMESTES Linnaeus



A

2(1). Prothorax without cavities for the reception of the antennae or, if cavities are present, they are not visible from frontal view. Dorsal surface always hairy, only rarely with a few patches of scale-like hairs among normal hairs....................3

   Prothorax with cavities for the reception of antennae (B); dorsal and ventral surface clothed entirely with triangular or broadly oval scales ....ANTHRENUS Fabricius

B

3(2). Hind tarsi with basal segment as long or longer than second..TROGODERMA Berthold 4

Hind tarsi with basal segment much shorter than second (C).....ATTAGENUS Latreille

4(3). Greatest width of male genitalia more than 2/3 the length of aedeagus (D)..........5

Greatest width of male genitalia less than 2/3 the length of aedeagus (E)..........8

5(4). Tergite of first periphallic segment almost straight at middle of distal margin(F)..6

Tergite of first periphallic segment forming an angle at middle of distal margin (G) ....simplex Jayne

6(5). Width of bridge of male genitalia narrower than aedeagus at point where they cross each other (H).........................7

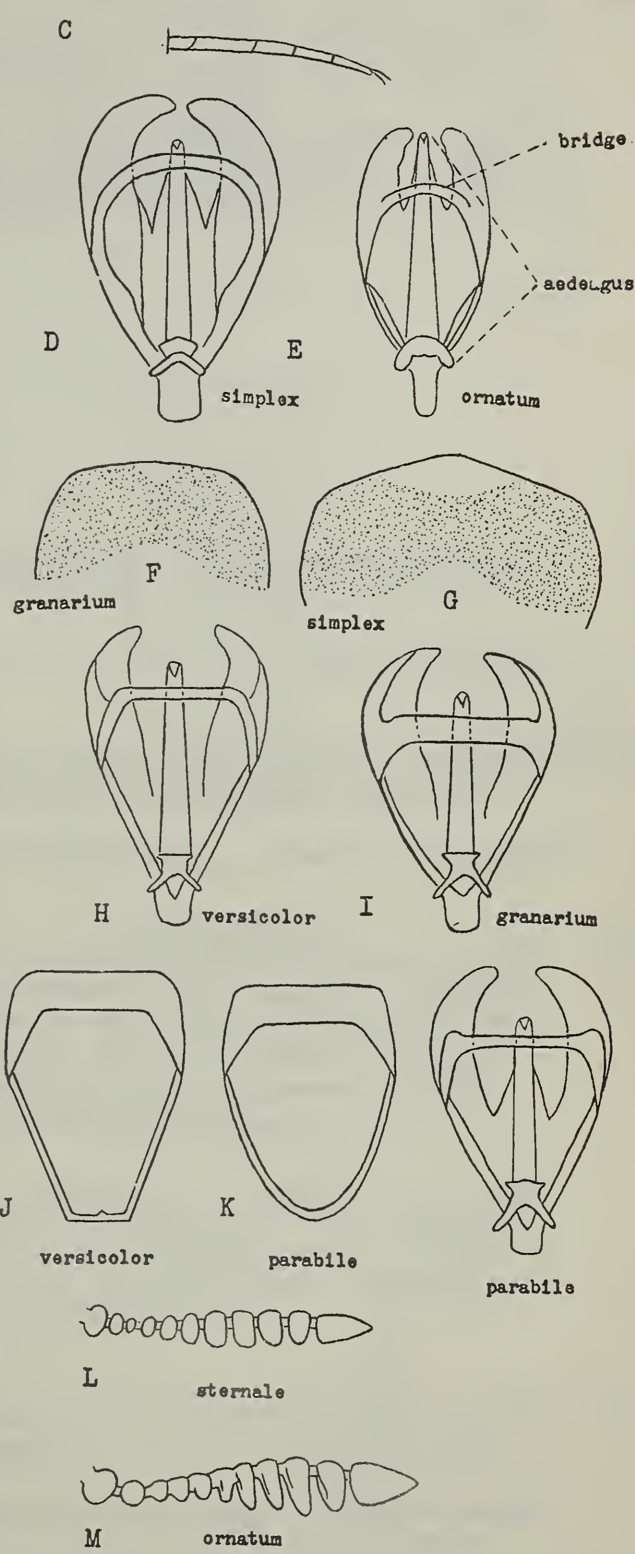
Width of bridge of male genitalia as wide or wider than aedeagus at point where they cross each other (I).....granarium Everts

7(6) Ninth abdominal segment or ring segment of male flattened ventrally (J); inner margin of eyes emarginated (A) versicolor (Creutzer)

Ninth abdominal segment or ring segment of male rounded ventrally (K); inner margin of eyes not emarginated.....parabile Beal

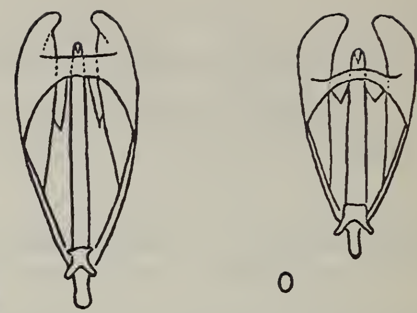
8(4). Third segment of male antenna minute, about 1/2 of either second or fourth segments in length and width; segments of club only moderately eccentric (L)...........9

Third segment of male antenna approximating second and fourth segments in length and width; segments of club decidedly eccentric or pectinate (M)..ornatum (Say)



9(8). Median section of bridge between lateral lobes of male genitalia more or less straight (N).............sternale Jayne

Median section of bridge between lateral lobes of male genitalia arched (O) .... grassmani Beal



N O

B. MATURE LARVAE

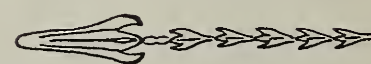
1. Urogomphi present on dorsum of 9th abdominal segment(A)..DERMESTES Linnaeus

Urogomphi absent..........................2

A

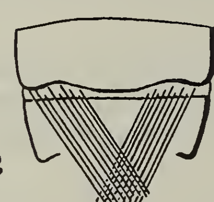
2(1). Hastisetae (spear-headed hairs) present on abdominal tergites (B)................3

Hastisetae absent.......ATTAGENUS Latreille



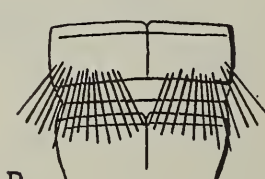
B

3(2). Tufts of hastisetae on abdominal tergites arising entirely from a membranous area on the caudo-lateral edge of segments; hastisetae from right and left sides usually converging over the cauda (C) ....ANTHRENUS Fabricius



C

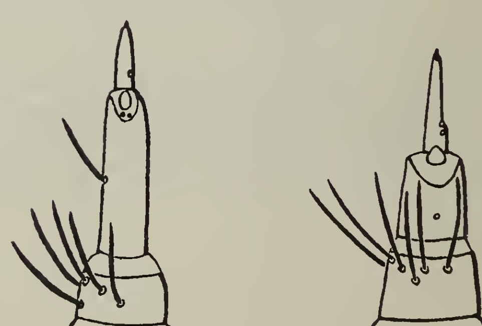
Tufts of hastisetae on abdominal tergites arising from the sclerotized dorsal surface of the segments; hastisetae not obviously convergent over the cauda (D) ....TROGODERMA Berthold 4



D

4(3). Second antennal segment 3 times length of 1st (E)..................simplex Jayne

Second antennal segment less than twice length of 1st (F).......................5

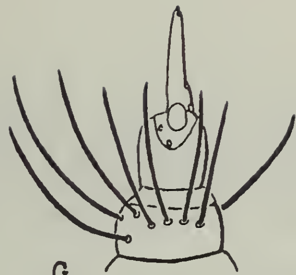


E F

simplex parabile

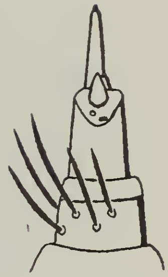
5(4). Setae of basal antennal segment arranged in a whorl, almost completely encircling the segment, setae not bunched on the mesal side of the segment (G)..........6

Setae of basal antennal segment bunched on mesal side of segment, 1/3 or more of the outer portion of the segment bare (H)...................................7



G

versicolor

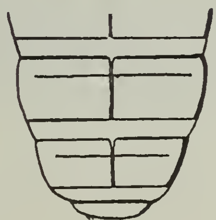


H

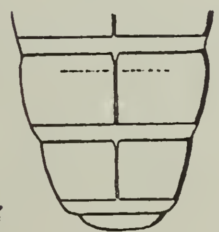
grassmani

6(5). Abdominal tergites 1 through 8 each bearing a transverse line (antecostal suture) near the anterior margin of the sclerotized area (I); 2nd antennal segment normally without setae (G) ....versicolor (Creutzer)

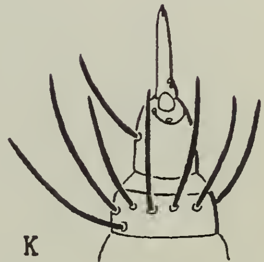
Abdominal tergites with antecostal suture on segments 1 through 6, but with suture faint or interrupted on 7th and usually absent on 8th (J); 2nd antennal segment with or without a seta (K) ....granarium Everts



I



J

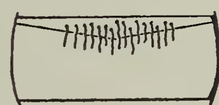


K

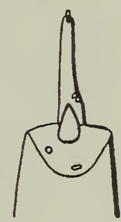
granarium

7(5). Setae of anterior portion (acrotergite) of 1st abdominal tergite all sufficiently long to extend caudad across the antecostal suture (L); accessory papilla of 2nd antennal segment extended distally into a sharp point (M)........8

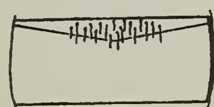
Setae of 1st abdominal acrotergite short, at least part of the more anterior setae not sufficiently long to cross the antecostal suture (N); accessory papilla of 2nd antennal segment rounded distally, not with a sharp point (O)&(F) ....parabile Beal



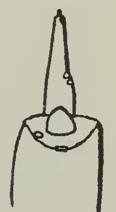
L



M



N



O

8(7). 2nd antennal segment without setae........9

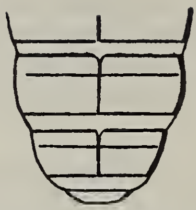
2nd antennal segment normally with one or two setae (P).............sternale Jayne

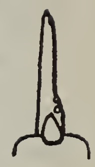
P

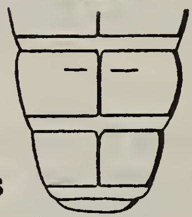
sternale

9(8). Antecostal sutures of 7th and 8th abdominal tergites extending completely across the tergites (Q); basal sensory pores of terminal antennal segment situated at about basal $\frac{1}{4}$ (R)&(H).....grassmani Beal

Antecostal sutures of 7th and 8th abdominal tergites not extending completely across the tergites, sometimes suture entirely absent on 8th segment (S); basal sensory pores of terminal antennal segment situated distad of basal 1/3 (T) ....ornatum (Say)


Q


R


S


T

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NOTE: Trogoderma versicolor (Creutzer) is now T. inclusum LeConte according to R.S. Beal Jr. 1956. Ent. Soc. Amer. Ann. 49(6):559-566.